Fall 11-1-2013

Identifying Optimal IT Portfolios to Promote Healthcare Quality

Kenneth Pinaire
Dakota State University

IDENTIFYING OPTIMAL IT PORTFOLIOS TO PROMOTE HEALTHCARE QUALITY

A graduate project submitted to Dakota State University in partial fulfillment of the requirements for the degree of

Doctor of Science

in

Information Systems

November, 2013

By
Kenneth Pinaire

Project Committee:

Surendra Sarnikar
Omar El-Gayar
Dorine Bennett
Viki Johnson

PROJECT APPROVAL FORM

We certify that we have read this project and that, in our opinion, it is satisfactory in scope and quality as a project for the degree of Doctor of Science in Information Systems.

Student Name: Kenneth Pinaire ______________________________

Doctorate Project Title: Identifying Optimal IT Portfolios to Promote Healthcare Quality

Faculty supervisor: ________________________________ Date: _____________

Committee member: ________________________________ Date: _____________

Committee member: ________________________________ Date: _____________

Committee member: ________________________________ Date: _____________

DISSERTATION APPROVAL FORM

This dissertation is approved as a credible and independent investigation by a candidate for the Doctor of Science in Information Systems degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this dissertation does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department or university.

Student Name: Ken Pinaire

Dissertation Title: Identifying Optimal IT Portfolios to Promote Healthcare Quality

Dissertation Chair: Surendra Sarnikar Date: 11/15/13

Committee member: Donnie Bennett Date: 11/15/13

Committee member: Viki Johnson Date: 11/15/13

Committee member: [illegible] Date: 11/15/13

DECLARATION

I hereby certify that this project constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions or writings of another.

I declare that the project describes original work that has not previously been presented for the award of any other degree of any institution.

Signed,

Kenneth Pinaire

ACKNOWLEDGMENT

To begin, I would like to acknowledge and thank my committee for their insights and guidance throughout this extended journey. Despite the multitude of their ongoing commitments to the university and to their many students, they were gracious enough to invest their time and expertise to assist me with this research.

In particular, I want to express my deepest appreciation to my committee chair, Dr. Surendra Sarnikar. His ability to convey complex concepts in an organized and logical manner made a difference by allowing me to expand my knowledge while connecting the dots. Dr. Sarnikar has been supportive throughout this multi-year process, often having more confidence in my success that I did. His continued emphasis on "telling the story" has proven beneficial to my research not only in this dissertation, but also in conference papers and presentations as well.

I want to also thank my parents Dale and Barb who early-on demonstrated and instilled a work ethic in me that allowed me to successfully juggle a family and fulltime employment while pursuing a fulltime education. They also taught me the importance of investing for the future. I have since discovered that there is no greater investment than in oneself.

To my brother Doug and his family, I want to thank them for assisting my wife and daughter in my absence, and for his stalwart example of that family work ethic.

I also wish to thank my work colleagues with whom I shared research ideas, and whose feedback and suggestions helped me solidify several concepts. Also, I offer my gratitude for their endless patience with my myopic conversations regarding my dissertation.

A strong technical acknowledgement and personal thank you goes to my colleague Robert Lapsley for his continued assistance with the frequent SQL data manipulations – even when my instructions were vague and I wasn't sure myself of what I wanted.

To my daughter Katie Beth whose laughter and cuddles motivated me to continually push forward, I look forward to making up for lost time. Finally but most important, I would like to thank my wife Kim. This has been a long road, and her sacrifice has been equal to mine each step of the way. Her support, encouragement and willingness to step into the gap allowed me begin this journey and see it to completion.

ABSTRACT

Healthcare organizations continue to make large investments in health information technology to improve quality of care and lower costs. Therefore, there is an ever-growing need to have an ever-clearer understanding of how IT investments impact these organizations. However, there are no methodologies designed to identify and then leverage these effects to promote healthcare quality. In this research, I present an extensive review of the literature on the impact of health information technology on the quality of care. A research gap is identified where past studies have explored the impact of individual technologies or aggregate all technologies based on overall investment, but do not explore the impact of specific portfolios of information technology and their synergistic effects on healthcare quality. Based on the past studies on portfolio theory, I introduce an approach, utilizing data mining techniques and logistical regression, to identify such optimal portfolios, and explore the presence of such synergistic effects among the components of the portfolio. This multi-step approach is then applied to publically-available datasets, and the resulting candidate IT portfolios are presented. Statistical analysis, controlling for specialty, ownership, size and case mix, is then used to test these results and demonstrate the feasibility of this approach. The results of this approach identify optimal portfolios for each of the healthcare metrics under study. Additionally, results from alternate analytical methods including cluster analysis and stepwise regression are also examined. Review of these results offers further support to the proposed approach. This approach identified 16 portfolios across the six healthcare metrics studied.

The primary contribution of this research is a new multi-step approach to identify optimal portfolios of information technology systems through the identification of intersystem synergies. This approach bridges three domains by borrowing well-established and commonly-accepted constructs from the information technology, business and healthcare arenas. Secondarily, the synergistic effects identified through the application of this approach offer insights into the use of current IT systems, as well as provide guidance in the development of future systems.

DECLARATION

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I declare that the project describes original work that has not previously been presented for the award of any other degree of any institution.

Signed,

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Kenneth Pinaire

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CHAPTER 1

INTRODUCTION

Healthcare Information Technology (HIT)

As the average age of the population in the United States increases, the demand for healthcare to treat them also rises. Currently, people aged 65 or older make up 12% of the population while accounting for more than 40% of the healthcare expenditure. The U.S. Census Bureau projects seniors will make up more than 20% by 2030 (U.S. Census Bureau, 2010). To support this growing need for healthcare, organizations seek ways to meet this need while simultaneously improving their performance. To this end, healthcare organizations continue to make large investments in health information technology to improve quality of care and reduce costs (Monegain, 2009; Pizzi, 2007). Research and Markets reported that in 2008, the value of the global Healthcare IT (HIT) market was estimated at $11 billion. They further estimate that by 2015, this value will more than double to $24 billion (Business_Wire, 2009). Other sources agree that the Healthcare IT market in the United States is anticipated to grow annually at a rate of more than 24% from 2012 to 2014 (Heathcare_IT_News, 2011). Furthermore, the United States government has promoted the Healthcare IT market by providing grants and financial incentives for research in, and the use of HIT systems. Examples of such health information technologies include large systems such as electronic medical records as well as specific components such as ePrescribing. Given the large investments, wide variety of technologies, and the critical nature of healthcare, there is clearly a need for a more thorough understanding of the impact of health information technology on healthcare. Specifically, it is important to evaluate and identify how specific technologies or a combination of technologies, designed to support patient care, impact the quality of care services and health outcomes.

Although there are several recent studies on the impact of IT on quality (Jamal, et al., 2009; Piontek, et al., 2010), conflicting findings on the impact of HIT on quality (Swanson Kazley & Diana, 2011), and the narrow technology focus of many studies (Wakefield, et al., 2010), has left the nature of the relationship between HIT and quality unclear. Most studies investigate individual information technologies or aggregate all information technologies into broad functional clusters without comparing the effect of specific combinations of technologies and their synergistic effects on quality of care. There is limited literature that explores the effect of portfolios of information technology and their effect on quality, and more specifically the optimal combination of technologies that result in the realization of quality benefits for healthcare organizations.

Seeking Optimal IT Portfolios

Given the large investments, wide variety of technologies, and the critical nature of healthcare, there is clearly a need for a more thorough understanding of the impact of health information technology on healthcare. Specifically, it is important to evaluate and identify how specific technologies or specific combinations of technologies designed to support patient care impact the quality of care services and health outcomes. Is an Electronic Medical Record system (EMR) sufficient to positively impact quality, or is the addition of a Decision Support system (DSS) required to realize these benefits? What mechanisms impact the care-giving process? It is likely and logical that complimentary systems such as EMR and DSS may generate a synergistic effect. However, what about more distantly related systems such as a Microbiology system and an Operating Room Scheduling system? Is there an unrecognized, but equally valuable, synergistic effect occurring between these systems? Only a clearer understanding of these intersystem dynamics will provide the necessary insights to maximize quality, and aid healthcare facilities in the development of strategic IT infrastructure planning.

To determine HIT's affect, we must first define what is meant by quality, and answer the question how do we measure it? For some authors quality is purely a quantitative measure based on the profit statement of the practice. Others define improvement to healthcare quality as employee satisfaction (McDowell, et al., 2008), increased availability, less expensive, quicker service, more informed patients, better physician - patient relationships (Ventres, et al., 2006) or the advancement of medical knowledge. However, most authors agree that improved quality of healthcare is achieved through a greater percentage of desired patient outcomes (Devaraj & Kohli, 2000).

In this research, I present a solution to assist healthcare facilities maximize the benefits to their quality of care from their current and future IT investments. To demonstrate the application and utility of this solution, a study was completed using a data mining-based approach that seeks to identify complementarities between HIT systems when used in conjunction within a healthcare setting. Specifically, I sought to discover if there exist portfolios of information technology that are associated with a positive effect on quality of care, and if there exist synergistic effects between the individual components of the portfolio.

In addressing the problem, this research seeks to offer several contributions. First, the primary contribution is the introduction of a unique two-stage approach that incorporates data mining and logistic regression analysis to effectively identify and test synergistic effects between IT systems. The portfolios resulting from the application of data mining component of this approach represent the candidate combinations of IT systems containing synergies that promote healthcare quality, while the analysis phase of this approach confirms the presence and magnitude of these synergies through the use of logistic regression. Second, applying this proposed approach will yield a set of contributions impacting the practitioner community. These include insights into HIT's influence on quality, which allows for more informed decisions regarding future investments as well as how to best leverage a facility's current infrastructure. Additionally, interactions between IT systems can guide development of next-generation systems to maximize their benefit. Third, this research draws from three domains (business, information systems, and healthcare) to introduce a novel application of the Portfolio Theory, a well-defined and accepted research model.

To accomplish this, the following four-steps were completed. 1. First, an extensive review of literature was conducted so that I would have a thorough understanding of the current state of research into intersystem dynamics within the healthcare field. In so doing, I identified studies that explore the effect of information technology on quality in healthcare, and also to identify theoretical models that explore the relationship between information technology investments and performance. 2. After finding a significant amount of research on IT in healthcare, but little on the impact of IT on healthcare quality, and no research utilizing the portfolios concept, a multi-step approach for identifying optimal portfolios that are positively associated with better quality outcomes is developed. 3. The validity of the proposed methodology is tested by subjecting a dataset to data mining techniques including multiple classifiers to identify candidate portfolios. 4. Finally, these candidate portfolios are further tested using regression analysis to confirm the presence or absence of a synergistic effect.

Outline of Dissertation

In the remaining chapters of this dissertation I highlight the importance of this research, detail the steps completed and discuss the results and conclusions drawn. Finally, limitations and future research opportunities are discussed.

In Chapter Two, Literature Review, I identify a research gap and explore literature to determine current perceptions and the status of HIT research. Each step of the systematic review is identified and explained as well as specific results revealed. Observations of current authors as well as their research focus and conclusions are summarized. I then return to the healthcare domain literature to help explain how the value of HIT assets has been assessed, and identify prior applications of the portfolio concept. Information from this second review of literature was used to provide a theoretical foundation and support for a new approach to addresses the research gap.

Chapter Three, Research Methodology, begins by detailing an application of the two-step portfolio-identifying approach. In the first step, data mining techniques are used to narrow the search space. The resulting candidate portfolios are then subjected to a regression analysis in the second step to identify the presence and magnitude of synergistic effects.

Chapter Four, Results and Discussion, discusses the results from the data mining process as well as the regression analyses. The synergistic results are highlighted and individual HIT systems are grouped into formal portfolios. These portfolios are identified along with the healthcare metric they impact. Additionally, I offer some insights which may be the basis for the observed synergies. Furthermore, alternative techniques to data mining, such as *k*-means and expectation–maximization cluster analysis, and step-wise regression, a possible alternative to logistic regression, are examined.

In the final Chapter 5, Conclusions, I offer a discussion of my research's contribution and impact, and I address how well the proposed approach addresses the initially identified research gap by identifying optimal HIT portfolios. I also identify the extent and severity of the study’s limitations and provide multiple suggestions as to avenues future research can take to incorporate this new approach.

CHAPTER 2

LITERATURE REVIEW

There is no value in undertaking research which, in the end, the results do not expand our knowledge or address an issue of concern. Because many of today's pressing issues already have a significant base of research, it is important for researchers to familiarize themselves with current literature. Healthcare and Information Technology are two examples of domains which contain a wealth of empirical research. Each broadly defined domain offers an abundance of enquiry, and while the subset of research encompassing both healthcare *and* IT is smaller, it is still extensive. To more fully understand the relationship between information technology and healthcare quality, in this research I explore several questions. What effect does healthcare IT have on quality? Are there specific technologies or a combination of technologies that lead to a positive impact on quality of care, and if there are, what systems are involved? The process to develop a more thorough understanding of how HIT affects healthcare quality required that I first must have a clear understanding of the current perspectives of domain researchers and the assumptions under which they work. To develop this understanding, I began with a systematic review of relevant literature. Literature reviews not only provide a holistic snapshot of the domain, they also offer insights into how research has developed industry knowledge over time, and how successful and generalizable specific techniques have been in the search to understand intersystem dynamics.

Search Strategy

The literature search strategy involved executing a search on the PUBMED database (www.ncbi.nlm.nih.gov/pubmed) seeking English language articles published between January 1, 2000 and June 30, 2013. The search terms used were "*Health Information Technology*" AND *Quality*. These terms were sought in all fields. The search returned 466 results. Many of the articles detailed healthcare worker or patient experiences, perceptions dealing with the use of IT systems, or detailed literature reviews. Others offered best practices to maximize benefits or IT investments. Each of the articles was reviewed, and from this pool only relevant articles were considered for inclusion in the analysis. Articles meeting the following criteria were considered relevant:

- The article reported on formal research conducted in empirical studies.
- The primary focus of the study is the implementation or use of HIT.
- The study identifies the effects of the implementation or use of HIT on the quality of service or patient outcomes.

Applying these criteria resulted in 50 articles. While the list of articles identified through the search process is not exhaustive, I believe it is a fair representation of recent domain literature, and provides a cross-section of not only technologies frequently studied but also of common implementation environments. Figure 1 outlines the methodology that produced these results.

Observations from Empirical Studies on the Impact of HIT on Quality

Each article was reviewed and where available details about study attributes were recorded. This included the specific HIT system, disease conditions under study, research methodology, extent of user base, context of technology use and adoption, outcome measures and facilitators and barriers to this adoption.

In terms of technologies, Electronic Medical Records (EMR) was the most commonly investigated technology (DesRoches, et al., 2010; Kern, et al., 2009). An electronic health record is a collection of all of a patient's data that would previously be found in the paper-based record. It contains all information including personal demographic information, a record of physician visits, chief complaints, and diagnostic results (e.g. radiology, laboratory, and cardiology), diagnosis and treatment details. This information is held and maintained in a digital form. The popularity of EMR's in research is not surprising since, although they have gotten a great deal of attention lately in the healthcare community due to legislative requirements, EMRs have been around for more than 20 years and are widely adopted by facilities and providers of all types. These patient record systems have been examined in conjunction with pediatric care (Adams, et al., 2003), ambulatory care (Bardach, et al., 2009;

Romano & Stafford, 2011), labor and delivery (Campbell, et al., 2008), prenatal care (Cochran, et al., 2011), primary care (El-Kareh, et al., 2009) and chronic care (Keyser, et al., 2009).

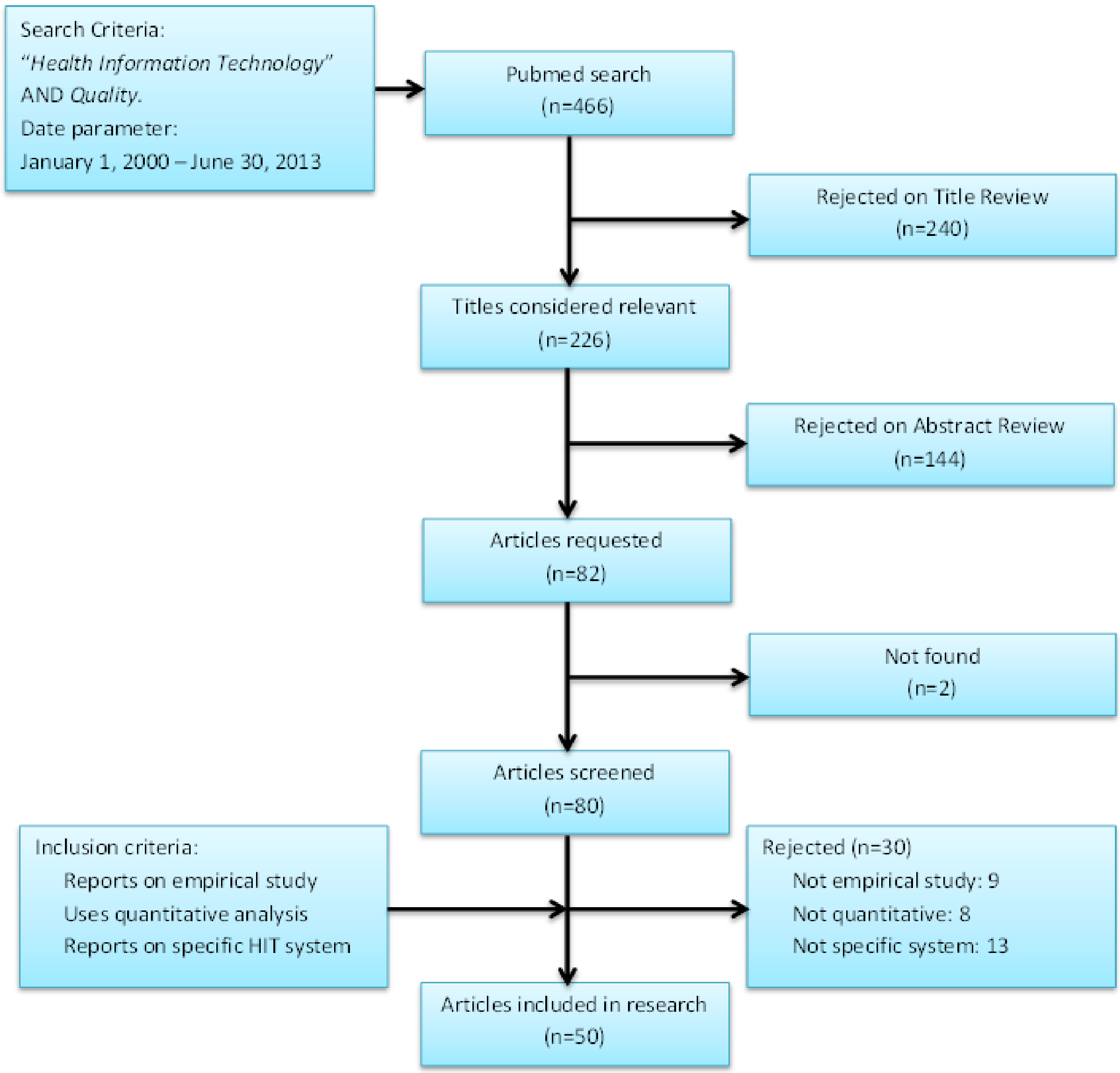

Figure 1: Literature Review Methodology

EMRs have also been examined in relation to specific diseases or diagnosis such as diabetes (Hunt, et al., 2009; Morin, et al., 2009; O'Connor, et al., 2005), asthma (Hazlehurst, et al., 2012), HIV (Schnall, et al., 2011; Virga, et al., 2012), and infections (Gluck, 2009), as well as in concert with other peripheral facility issues such as privacy and costs (Gaylin, et al., 2011), and patient satisfaction (Restuccia, et al., 2012). Researchers have also examined EMR's impact on quality in specific types of healthcare facilities such as retirement homes (Pillemer, et al., 2011), academic versus non-academic hospitals (McCullough, et al., 2010), hospitals versus primary-care clinics (Nirel, et al., 2010; Nirel, et al., 2011), or home healthcare (Russell, et al., 2010)

EMR's popularity in research was closely followed by Computerized Physician Order Entry's (CPOE) impact on quality (Swanson Kazley & Diana, 2011). In a CPOE system, a caregiver can enter instructions for the treatment of patients electronically. This type of system is most commonly found in hospitals as one of the primary benefits of this type of system is that the orders can be immediately communicated across a computer network to all departments such as the laboratory, pharmacy, radiology or the operating room. CPOE systems decrease the delay in order communication, which in turn reduces the time for completion.

The impact of Computerized Physician Order Entry systems on quality in relation to specific conditions such as pregnancy (Deily, et al., 2013), and specific hospital departments such as pharmacy (Koppel, et al., 2005) has also been examined. Additionally, the results of CPOE's presence in academic versus non-academic hospitals (McCullough, et al., 2010), and home healthcare (Russell, et al., 2010) have been reported.

The third HIT frequently appearing in literature is Clinical Decision Support Systems (CDSS). A CDSS is a software-driven decision-making tool which is designed to assist physicians and other health professionals with decision making tasks, such as developing a patient diagnosis. To this end, the physician can use a CDSS to combine patient data, industry best-practices and medical knowledge to reduce delay and improve accuracy (DesRoches, et al., 2010). Data mining may be used to examine the patient's medical history in combination with recent medical research. This complex analysis can help prevent potential adverse events such as drug interactions (Roberts, et al., 2010).

There are two main types of clinical decision support systems. The first type of CDSS uses a knowledge base and applies rules to patient data using an inference engine. The results are then displayed to the user. The second type of system does not utilize a knowledge base, but rather it relies on machine learning to analyze the patient's data. Here too, researchers have reviewed CDSSs focusing on types of care such as intensive care (Fraenkel, et al., 2003), ambulatory care (Romano & Stafford, 2011), and home healthcare (Russell, et al., 2010). Much like the other technologies discussed, the results of CDSSs on specific conditions have also been reported including hypertension (Jean-Jacques, et al., 2011; Shelley, et al., 2011), and ulcers (Sharkey, et al., 2013).

Finally, an Adverse-Drug-Event Alert Systems (ADEAS) was the focus in multiple articles. An ADEAS is an advanced clinical decision support system which specializes in alerting providers to potential drug interactions and patient allergies. These systems are typically rules-based, and will also reference patient laboratory results when specific drugs are ordered and alert physicians when potentially dangerous conditions exist (Piontek, et al., 2010; Roberts, et al., 2010).

Both qualitative and quantitative research methodologies were employed to investigate the impact of HIT on quality with some authors using both methodologies (Campbell, et al., 2008; DesRoches, et al., 2010; Golob, et al., 2008). Qualitative researchers study phenomena in their natural settings and attempt to understand or to interpret its meaning. Qualitative research is intended to derive the more profound meaning of the subject matter, and it involves an interpretive, naturalistic approach. On the other hand, quantitative research attempts to explain phenomena through the collection of numerical data which are then analyzed using statistic-based methods. Quantitative research involves a formal, empirically objective and systematic approach. Although some people assume that qualitative research and quantitative research are converse concepts, they can be complementary when used in conjunction.

However, in further analysis, only those studies utilizing quantitative analysis methods (either in isolation or in conjunction with qualitative methods) were used to maximize relevance to the proposed research. As mentioned earlier, most studies focused on the specific technologies of EMR, CPOE, CDSS and ADEAS. However, several articles reported on HIT's impact collectively and focused on a specific health outcome or quality metric rather than a specific HIT system. For instance, quality metrics for diseases such as asthma (Kern, et al., 2009), breast cancer (Loiselle, et al., 2010), and mental health (Cohen, et al., 2013) were examined to ascertain the impact of the entire facility's HIT infrastructure on performance.

Most studies use one of two units of analysis when determining if benefits had been realized after implementation. A unit of analysis is the most fundamental component of scientific research. The unit of analysis is the primary object that is being analyzed in a study. As detailed in Table 1, about half of the studies focused on the facility by comparing a facility's performance measure (e.g. mortality rate) (Piontek, et al., 2010) pre and post implementation of an HIT system to judge results. The remaining half of the studies used the patient as the unit of analysis (e.g. glucose levels, blood pressure) (Hooper, et al., 2013; Hunt, et al., 2009) to determine impacts. In almost all cases, longitudinal data was required to ensure temporality and thus support the author's causality conclusions.

Table 1. Units of Analysis Used in Literature

Unit of Analysis	Articles	Strong Positive	Mixed Results	Strong Negative
Facility	22	12	7	3
Patient	16	9	5	2

As mentioned earlier, quality is a construct that requires further clarification as many authors have interpreted it differently in different contexts. Quality can be reflected in profit/loss statements, employee turnover (McDowell, et al., 2008), patient wait times, reduced costs, more engaged patients (Ventres, et al., 2006) or simply as the continual advancement of medicine. However, most authors, and for the purpose of this study, quality is defined as improved healthcare achieved through a greater percentage of desired patient outcomes (Devaraj & Kohli, 2000).

Research Gaps Identified in Literature

As is evident in Table 2, there is no clear consensus regarding a positive or a negative impact of information technology on healthcare quality. While many studies offered strong support for the implementation of HIT (Nirel, et al., 2011; Wakefield, et al., 2010), almost as many found either marginal benefits (Romano & Stafford, 2011; Swanson Kazley & Diana, 2011), improvements to quality from some IT systems and not others (DesRoches, et al., 2010), or benefits for only some patients (Loiselle, et al., 2010).

Table 2. Summary of Empirical Research on Impact of IT on Healthcare Quality

Technology	Positive	Neutral	Negative	Inconclusive
EMR	Adams, et al., 2003; Campbell, et al., 2008; El-Kareh, et al., 2009; Gaylin, et al., 2011; Gluck, 2009; Hunt, et al., 2009; Nirel, et al., 2009; Cochran, et al., 2011; Hazelhurst, et al., 2012; Restuccia, et al., 2012	DesRoches, et al., 2010; McCullough, et al., 2010; O'Connor, et al., 2005; Romano & Stafford, 2011; Pillemer, et al., 2011	Kern, et al., 2009; Morin, et al., 2009	Bardach, et al., 2009
CPOE		McCullough, et al, 2010; Swanson & Diana, 2011	Koppel, et al., 2005; Roberts, et al., 2010	
CDSS	DesRoches, et al., 2010; Fraenkel, et al., 2003; Jean-Jacues, et al., 2011; Shelley, et al., 2011	Romano & Stafford, 2011	Roberts, et al., 2010	
Other	Golob, et al., 2008; Davis & Pavur, 2011; Menachemi, et al., 2008; Piontek, et al;, 2010; Yu & Houston, 2007; Spielberg, et al., 2011; Lucero, et al., 2011; Sharkey, et al., 2013; Virga, et al., 2012; Restuccia, et al., 2012; Frimpong, et al., 2013; Cohen, et al., 2013; Hooper, et al., 2013	Davis & Pavur, 2011	Furukawa & Adam 2008; Loiselle, et al., 2010; Gluck, 2009	Savage, et al., 2010; Deily, et al., 2013; Campion, et al., 2013

Interestingly, according to the Yu & Houston (2007) study, it also appears that the quality performance of a healthcare facility is a strong predictor of IT adoption, but information technology adoption is not a strong predictor of improved quality (Figure 2). This indicates that technology adoption alone is not sufficient to realize quality benefits, and that the way in which technology is used does have a significant influence on the direction and extent of quality impacts. This is also reinforced by the Tavakoli et al. (2008) study where workflow changes combined with existing technology is shown to yield better quality outcomes.

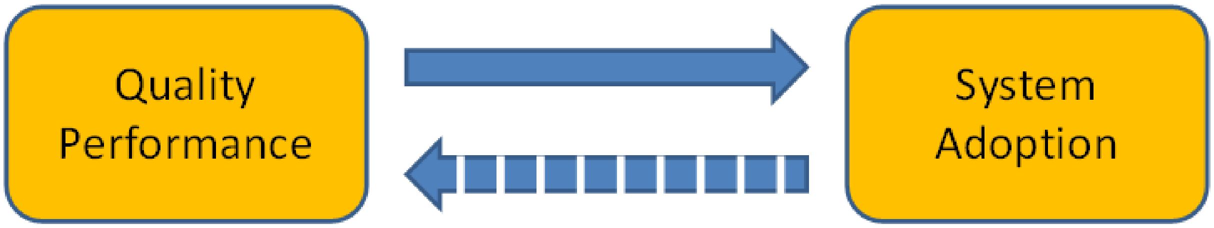

Figure 2. Performance vs. Adoption Prediction Relationship

Some of the papers reviewed were of particular interest as they offered specific insights from their study's perspective, but when taken in totality offer clear trends in research results. For instance, Piontek, et al. (2010) pointed out that medical errors and undesirable outcomes are costly. Therefore, as the severity-adjusted mortality rates of facilities declined due to the implementation of an adverse-drug-event (ADE) alert system, so did pharmacy and variable drug costs. Additionally, in the process of protecting patient health, a peripheral benefit of HIT systems may be physician education. Roberts, et al. (2010) reveal the number of true positive alerts from an ADE alert system declined over time. This may indicate that the alerts caught by the system informed prescribers who in turn became more familiar with drug interactions; thereby reducing the occurrence of prescription errors. Contrarily, Savage, et al. (2010) warns that the more complex an ePharmacy (and by extension, any HIT system) is, the more opportunity exists for the introduction of errors. When healthcare providers begin to rely entirely on the computerized system to make decisions regarding dosage, drug interaction and discharge orders, oversights can occur. These errors are almost always a result of incomplete or inaccurate information entered on the patient's behalf.

In some literature evaluating the impact of technology on healthcare quality, patterns emerged that are in line with the DeLone and McLean model for Information System success (DeLone & McLean, 1992). Specifically, system quality, information quality, and use are identified in many papers as being key factors that influence the realization of quality benefits of information systems (Furukawa & Adam, 2008; Hynes, et al., 2010). However, other studies counter these arguments by concluding patient socio-economic status (Loiselle, et al., 2010) or information system mix (Myung Ko & Osei-Bryson, 2004) were stronger predictors of quality. Some studies also indicate that quality focused information systems such as quality reporting and benchmarking (Hunt, et al., 2009) or drug interaction and adverse drug event systems offered more benefits than general health information technologies such as EMR when evaluated with respect to impact on quality (DesRoches, et al., 2010). There does appear to be a greater focus on healthcare quality among the HIT community. From 2000 through 2011 there were 321 articles which met the search requirements. This averages to about 29 articles per year during that period. From 2012 through June, 2013 there were 145 articles archived by PubMed. This is an average of approximately 96 articles per year, and indicates that the topic of healthcare quality is gaining additional attention from both the healthcare and information technology domains. This growing attention lends increasing support to the need for clearer understanding of the impact of HIT on healthcare. The growing body of research acknowledges the desire of healthcare providers, insurance companies and IT professionals to find ways to maximize the benefits offered by HIT.

Theory Development

In support of this growing need to understand HIT's impact on quality, and to address this gap in research, domain literature was once again reviewed to identify an appropriate model or theoretical framework on which to base the research. This review looked at evaluations of information technology investments as well as examples of evaluations of capital investments in healthcare. Where possible, articles were specifically sought that combined both domains by reporting on evaluations of IT investments *in* healthcare.

The resulting review revealed recent articles that evaluated investments in business and healthcare. The Bendoly, et al. (2009) research explores the impact of Enterprise Resource Planning (ERP) systems on profitability of manufacturers. They concluded that information efficiency was a strong predictor of profitability. whereas Menon, et al. (2000) looked at IT collectively, and its impact on production of services within a hospital. Their findings indicate that IT contributes positively to productivity. Ancker, et al. (2011) suggest that the reason for varying results from past studies investigating the impact of IT on healthcare quality is due to the selection of evaluation frameworks. Their solution is to apply their proposed Triangle Model which takes into account (1) system usage, (2) organizational support, and (3) organizational policies. The DeLone and McLean IS Success Model has been applied to mobile work within a hospital by Chatterjee, et al. (2009). The result of this study is a revised model which is applicable only to mobile work. Cresswell, et al. (2010) offer another approach to evaluate IT using the Actor-Network theory to explain complex relationships. However, their research was limited to only the examination of Electronic Medical Records.

Several theories have been used to evaluate impact of IT on performance. The term *performance* in the healthcare arena can be further divided into *fiscal performance* and *quality performance*. Although this research focuses on *quality performance*, it is useful to examine how all performance has been appraised as evaluation techniques may be transferable to the quality perspective. As outlined in Table 3, it appears that no single theory dominates IT investment evaluation. The authors of the reviewed articles were guided by numerous models, theories and frameworks. Select papers used mature and well accepted tools such as DeLone and McLean's IT Success model (Chatterjee, et al., 2009), the UTAUT model (Hennington & Janz, 2007), and Data Envelopment Analysis (Bendoly, et al., 2009; Valdmanis, et al., 2008). Others more recently proposed models include the Actor-Network model (Cresswell, et al., 2010), and Triangle model (Ancker, et al., 2011).

Table 3. Select Studies Evaluating IT and Healthcare Investments

Study	Context of Study	Guiding Theoretical Framework	Constructs and Measures	Data and Method
Ancker, et al., 2011	e- prescribing	Triangle Model	Organization - Technology - Processes	Controlled for years in practice & training
Valdmanis, et al., 2008	Urban US hospitals	Data Envelopment Analysis	Labor hours vs. quality	AHRQ & HCUP database
Hennington & Janz, 2007	Adoption of EMR	UTAUT Model	Contextual variables affecting adoption	Literature review analysis
Bendoly, et al., 2009	Manufacturers	Data Envelopment Analysis	Performance frontier	ERP system adopters
Myung Ko & Osei-Bryson, 2004	IT adoption in hospitals	Theory of production	Labor and capital	Washington DOH database, MARS
Menon, et al., 2000	Washington state hospitals	Theory of revenue maximization	Labor and capital	Longitudinal behavior model
Chatterjee, et al., 2009	Mobile IT platforms	DeLone and McLean IT Success Model	Quality, use and satisfaction	Systematic literature review and analysis
Cresswell, et al., 2010	EHR software in hospitals	Actor-Network Theory	Complexity and fluidity of reality	Semi-structured interviews
Thrasher, et al., 2006	130 delivery systems	Strategic Alignment Model	Strategic fit	Length of stay, operational costs

While the studies above contribute significantly to help develop an understanding of the impact of information technology on healthcare, many of the studies either consider the impact of specific information technologies in isolation, focus on productivity and financial metrics, or aggregate several technologies into functional clusters to investigate their impact on hospital performance. Specifically, there are no studies that explore specific combination of technologies, and the synergies between various information technologies and their impact on quality of care. Portfolio theory is a potential theoretical framework that can help investigate the impact of synergies between information technologies. Portfolio theory suggests that a collection of diverse resources are used to minimize risk and maximize business opportunities (Lin, et al., 2006).

In order to understand the impact of portfolios and synergies, I identified and evaluated a subset of articles that explored the impact of technology portfolios on organizational performance (Table 4). These articles are particularly relevant as they provide a precedent for using the portfolio theory in the analysis of both information technology and healthcare investments. The Lin et al. paper investigates how the configuration and variation of a facility’s patent portfolio can create synergy and, therefore, contribute to improved organizational performance. The authors were concerned with two countering views on whether technology diversity or strategic focus offered the greatest boost to performance. In this paper, improved performance is defined as increased profitability and increased share-holder value. The authors highlight technology adoption as a moderator between the relationship of technology diversity and firm performance. They also suggest that technology development and adoption by a firm should be a strategic activity where organizational leadership looks to compliment the current technology portfolio with future IT research and development. Lin, et al. indicate, “…a synergistic effect is expected so that the value of a technology portfolio can add up to more than the sum of its separate parts” (2006).

Bridges, et al. (2002) further confirms portfolio theory is an appropriate choice for simultaneous analysis of multiple healthcare investments. In their research, the authors concede that portfolio theory has been essential to the analysis of risk in many areas of economics. However, it is seldom applied to the health care arena. Their research looked at the use of portfolio theory in the context of cost-effectiveness analysis (CEA). They suggest that the theory must undergo a number of modifications in order to apply to the fiscal assessment of health care interventions. These modifications include adjusting assumptions regarding, and the method of reporting, the results of a CEA. Second, portfolio theory results need to be reported in the context of the effects on patients at the population level. Finally, and I believe most importantly, allowances must be made for the possibility of synergistic effects between the various health treatments and procedures. They conclude that, while this modified portfolio theory adds to the theoretical foundation of health care assessments, it may not be operational until a better understanding of the correlation between treatments and procedures are available. This conclusion supports my contention that a more thorough understanding of the intersystem synergistic relationships is fundamental to the application of portfolio theory to HIT.

Table 4. Studies Evaluating IT and Healthcare Investments Using Portfolio Concept

Study	Context of Study	Guiding Theoretical Framework	Constructs and Measures	Data and Method
Bridges, et al., 2002	Multiple interventions to standardize returns	Portfolio Theory	Synergy between health investments	Cost effectiveness analysis
Lin, et al., 2006	Identify if patent diversity reduces risk	Technology portfolio strategy	Synergy from IT portfolio	US Patent applications
Zhu, 2004	114 companies using e-commerce	Resource-based theory	Complementary IS	Inventory of IT, financial records
Setia, et al., 2011	IT application assimilation and use	IT portfolio Theory	IT systems and net income	HIMSS & California OSHPD
Thrasher, et al., 2010	Health Alliance networks	Thompson's Interdependence Theory	Complementary IS	Financial and quality results performance

The complimentary effects of IT systems are well supported by Zhu's (2004) examination of firms' technology infrastructure and e-commerce capabilities. His study sought to determine the value of e-commerce capabilities and information technology infrastructure. He incorporated the resource-based theory of the firm into their research and developed a framework through which they were able to test the main effects as well as the interaction effects of e-commerce and information technology on a firm's performance. While using firm size and sub-industry effects as control variables, he found a strong positive synergistic effect between IT infrastructure and e-commerce capability. Using sales per employee, inventory turnover, and cost reduction as metrics, he concluded that this interaction positively impacts a firm's performance. This study used sales per employee, inventory turnover, and cost reduction as metrics. His results provide further empirical evidence to the complementary synergies between components of the IT infrastructure. The author further discusses the "productivity paradox" which, for many organizations, is where additional investment in IT assets does not equate to an equal increase in productivity. He suggests the complementary effects found, in this study, between IT infrastructure and e-commerce may help to counter this contradiction. The author's findings further support the performance vs. adoption relationship discussed earlier in which adoption of IT alone is not a strong indicator of performance.

Thrasher et al.'s (2010) research into the synergies realized from integration of multiple health care alliance networks examined the complementarity of IT with process and decision-making integration (PDM). Their research was particularly interesting because they looked at benefits gained through inter-organizational synergies. Connecting and leveraging HIT systems between health care alliance network members further enhances the benefits available from a portfolio of systems working within a single organization. They recommend that further research should include longitudinal data, and fully examine how the manner in which the systems are integrated affects their resulting combined synergistic effect.

Setia et al.'s (2011) offers an analysis of how the integration of IT applications affect the financial performance of healthcare organizations. The authors identify two dimensions of IT integration and use. The first is the IT applications *architecture spread*. This dimension details the breadth and range of IT solutions in use within a facility. The second dimension is the IT applications *architecture longevity*, which is the extent of expertise of, and length of time with adopted IT solutions. They examined the extent to which these two dimensions of integration impact hospital performance. In their study, the analysis was completed by using net income as the dependent variable and performance metric. Setia et al.'s conclusions include suggesting that the synergies between these dimensions are important factors impacting hospital financial performance with *architecture longevity* providing the greater of the impact.

When looking at results from multiple studies, it still appears that HIT's impact on the quality of healthcare is ambiguous at best. However, there are growing signs that HIT is maturing, and benefits are beginning to be realized more reliably. Nine of the ten most recent articles included in this research reported favorable results compared to only five of the ten oldest articles appearing in this review. While only an antidotal observation, this may warrant further research as systems become more comprehensive, user friendly, and interoperable. What is clearer is that there are mitigating aspects affecting the impact of these technologies, and in some cases these dynamics are impeding their potential benefits. A more thorough understanding needs to be developed of these factors through an in-depth examination of dependent and independent variables.

No study has yet looked at specific combinations of IT systems to understand how systems interact, determine if synergies exist, and if they do exist, how to maximize these synergies to promote healthcare quality. Research into optimal portfolios can provide the insights necessary to close this gap. This research seeks to address these needs by providing an approach to identify and benefit from these intersystem dynamics through the identification of optimal portfolios.

CHAPTER 3

RESEARCH METHODOLOGY

Based on the past research that indicates that the complementarity and the synergistic effects between technologies in a portfolio is a key factor in influencing performance, in this study I sought to identify such optimal portfolios that positively influence patient-outcome quality at healthcare organizations. The interactions between IT systems and the varying levels of synergies they provide may help explain the discrepancies reported by the authors of studies discussed earlier.

Specifically, this research was guided by the following two objectives:

Research Objective 1

Identify portfolios of information technology that are positively associated with better than average quality performance at healthcare organizations

Research Objective 2

Identify if synergistic effects exist between the components of the IT portfolios. Specifically, are individual technologies more positively associated with quality when used in conjunction with other technologies within an IT portfolio than when used in isolation?

To build on the portfolio theory applications outlined in the previous section, I tested the research model depicted in Figure 3.

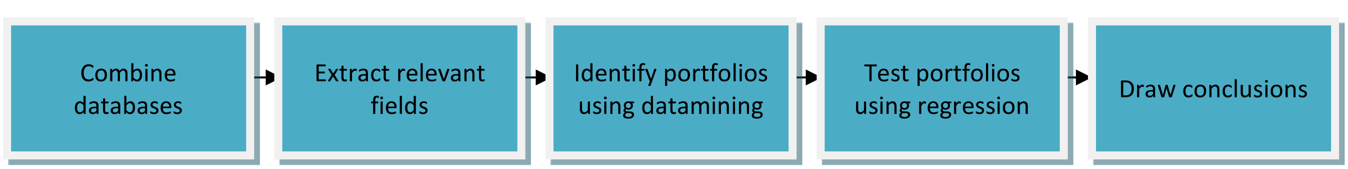

Figure 3. Research Methodology

The process begins with locating and securing suitable datasets. A suitable dataset would contain data on multiple healthcare providers, the information technology systems and applications they use, and the results of one or more healthcare quality metrics. For this research multiple datasets had to be combined in order to meet these requirements. Once the dataset was successfully merged, the required fields were identified and imported into a new database for ease of manipulation.

The third step involved applying data mining techniques through the use of decision tree classifiers to highlight candidate portfolios. These candidate portfolios where then subjected to statistical analysis to reveal intersystem synergies. Finally, optimal portfolios were identified and discussed. The rest of Chapter 3 details the process in each of these steps.

Data Collection, Merge and Manipulation

To address the research question regarding HIT's impact on quality, an analysis of hospital IT adoption records in conjunction with hospital quality results was completed. Specifically, a multi-source approach to data collection was used incorporating the 2009 HIMSS Analytics database, and the 2010 version of the AHRQ Hospital Compare database available at Medicare.gov.

In July, 2004, the Dorenfest IHDS+ Database transitioned into HIMSS Analytics. HIMSS Analytics is a not-for-profit organization and a subsidiary of the Healthcare Information and Management Systems Society (HIMSS). HIMSS makes non-current versions of this database available to university students as a valuable resource to assist in developing models which gain a deeper understanding of the role information technology plays in the healthcare arena. Beyond standard demographic information such as type of facility (clinic, physician's office, hospital, etc.), specialty (teaching, cancer, veteran, etc.), and geographic region, these details report on each facility's IT infrastructure. Table 5 identifies a selection of IT-specific components available in this dataset.

The Hospital Compare database is published by the U.S. Government's Center for Medicare which falls within the Department of Health and Human Services (DHHS). Data is collected from care facilities that participate in the Medicare program. Except for veteran and Shriner's hospitals, virtually all healthcare facilities participate in Medicare. The database reports on 4,726 acute care, critical access and children's facilities, and is the backend data repository which services their website.

Table 5. IT Infrastructure Components Reported in HIMSS Dataset

Software Applications	Telecom Services/Equipment	Internet Services/Providers
Handheld Devices	Wireless Access/Security	Hardware Brands/Models
Long-Term Data Storage	Bar Coding	System Vendors
PACS Components	How System was Used	Disaster Recovery Plan

Both the HIMSS and Medicare.gov datasets are updated annually, and were provided in Microsoft Access format. For ease of manipulation, each dataset was imported into a new Microsoft SQL database.

Independent Variables

The HIMSS database is a comprehensive source of IT market intelligence. This organization adminsiters an annual survey where healthcare administrators are asked about their facility's IT infrastructure. This datasource identifies the IT applications in use (independent variables) for more than 34,000 healthcare facilities within the United States. The breadth and depth of the inquiry has expanded incrementally over several years to include datacenter applications. These applications were clustered into clinical and business/strategic groupings (Table 6). These clusters were adapted from Setia et. al. (2011) and Bhattacherjee et. al. (2007) with the additional classifications of recently introduced applications. Clustering HIT in this manner has been extensively validated, and is commonly used by researchers in this field (Burke & Menachemi, 2004; Burke, et al., 2002; Dorenfest, 2000; Nir Menachemi, et al., 2006; Pare & Sicotte, 2001). The Clinical HIT cluster included applications designed to improve patient care. Because the direct impact of IT systems on healthcare outcomes was sought, only clinical systems were used in the analysis.

Table 6. HIT Application Clusters

Clinical HIT	Administrative/Strategic HIT
1. Abstracting	1. Accounts Payable
2. Ambulatory EMR	2. ADT/Registration
3. Ambulatory Laboratory	3. Bed Management
4. Ambulatory PACS	4. Benefits Administration
5. Ambulatory Pharmacy	5. Browser
6. Ambulatory Radiology	6. Budgeting
7. Anatomical Pathology	7. Business Intelligence
8. Blood Bank	8. Case Mix Management
9. Cardiology - Cath Lab	9. Clinical Data Repository
10. Cardiology - CT (Computerized Tomography)	10. Contract Management
11. Cardiology - Echocardiology	11. Cost Accounting
12. Cardiology - Intravascular Ultrasound	12. Credit/Collections
13. Cardiology - Nuclear Cardiology	13. Data Warehousing/Mining - Clinical
14. Cardiology Information System	14. Data Warehousing/Mining - Financial
15. Chart Deficiency	15. DBMS
16. Chart Tracking/Locator	16. Disaster Recovery System
17. Clinical Decision Support System (CDSS)	17. Email
18. Computerized Practitioner Order Entry (CPOE)	18. Encoder
19. Consumer Portal	19. Encryption
20. Dictation	20. Enterprise Master Person Index (EMPI)
21. Dictation with Speech Recognition	21. Enterprise Resource Planning
22. Document Management	22. Executive Information System
23. Electronic Data Interchange (EDI)	23. Financial Modeling
24. Electronic Forms Management	24. Firewall
25. Electronic Medication Administration Record (EMAR)	25. General Ledger
26. Emergency Department Information System (EDIS)	26. Interface Engines
27. In-House Transcription	27. Materials Management
28. Intensive Care	28. Medical Necessity Checking Content
29. Laboratory - Molecular Diagnostics	29. Nurse Acuity
30. Laboratory - Outreach Services	30. Nurse Staffing/Scheduling
31. Laboratory Information System	31. Patient Billing
32. Microbiology	32. Patient Scheduling
33. Nursing Documentation	33. Payroll
34. Obstetrical Systems (Labor and Delivery)	34. Personnel Management
35. Operating Room (Surgery) - Peri-Operative	35. Practice Management
36. Operating Room (Surgery) - Post-Operative	36. Spam/Spyware Filter
37. Operating Room (Surgery) - Pre-Operative	37. Time and Attendance

38. OR Scheduling	38. Web Development Tool
39. Order Entry (Includes Order Communications)	
40. Outcomes and Quality Management	
41. Pharmacy Management System	
42. Physician Documentation	
43. Physician Portal	
44. Radiology - Angiography	
45. Radiology - CR (Computed Radiography)	
46. Radiology - CT (Computerized Tomography)	
47. Radiology - DF (Digital Fluoroscopy)	
48. Radiology - DM (Digital Mammography)	
49. Radiology - DR (Digital Radiography)	
50. Radiology - MRI (Magnetic Resonance Imaging)	
51. Radiology - Nuclear Medicine	
52. Radiology - Orthopedic	
53. Radiology - US (Ultrasound)	
54. Radiology Information System	
55. Respiratory Care Information System	
56. Single Sign-On	
57. Transcription - Remote Hosted/ASP	

Dependent Variables

One source of data was retrieved from the federal government. The Medicare's Hospital Compare database provided quality measures representing patient results (dependent variables) for 4,726 facilities nationwide. This database was created through the efforts of the Centers for Medicare & Medicaid Services (CMS), in collaboration with organizations representing consumers, hospitals, doctors, employers, accrediting organizations, and other federal agencies. This database is updated yearly and offers data on:

- Timely and effective care
- Readmissions, complications and deaths
- Use of medical imaging
- Survey of patients' experiences
- Number of Medicare patients
- Medicare payment

The readmissions, complications and deaths details were utilized for this research. Within this portion of the data, healthcare facilities were rated by the Agency for Healthcare Research and Quality with one of three ordinal values, *above the national average*, *equal to the national average* or *below the national average* for each of six quality measures (Heart Attack Mortality, Heart Attack Readmission, Heart Failure Mortality, Heart Failure, Readmission, Pneumonia 30 Day Mortality, and Pneumonia Readmission). The national averages for these six metrics are identified in Table 7.

Table 7. National Quality Rates

Measure	National Rate
Pneumonia (PN) 30-Day Readmission Rate	18.4
Heart failure (HF) 30-Day Readmission Rate	24.8
Acute Myocardial Infarction (AMI) 30-Day Readmission Rate	19.8
Pneumonia (PN) 30-Day Mortality Rate	11.9
Heart failure (HF) 30-Day Mortality Rate	11.3
Acute Myocardial Infarction (AMI) 30-Day Mortality Rate	15.9

The Agency for Healthcare Research and Quality (AHRQ) define the six quality metrics as:

Heart Attack Mortality

This measure is used to assess the risk-adjusted rate of all in-hospital deaths occurring within 30 days of first admission to an acute care hospital for adults with a diagnosis of acute myocardial infarction (AMI). The value reflects the number of deaths from all causes occurring in hospital within 30 days of admission for acute myocardial infarction (AMI) divided by the total number of acute myocardial infarction (AMI) episodes in an 11-month period (National Quality Measures).

A “heart attack” occurs when the blood supply to the heart muscle is interrupted, starving it of oxygen and causing the muscle to die. This happens when one of the heart's own blood vessels becomes blocked ("Heart Attack vs. Heart Failure," 2013).

Heart Attack Readmission

This measure is used to assess the risk-adjusted rate of unplanned readmission following discharge for acute myocardial infarction (AMI) for individuals between 15 and 84 years of age. A case is counted as a readmission if it is for a relevant diagnosis and occurs within 28 days after the AMI episode. An episode of care refers to all contiguous inpatient hospitalizations and same-day surgery visits. This value reflects the number of acute myocardial infarction (AMI) episodes with a readmission for a given year divided by the total number of acute myocardial infarction (AMI) episodes in an 11-month period (National Quality Measures).

Heart Failure Mortality

This measure estimates a hospital-level risk-standardized mortality rate (RSMR), defined as death from any cause within 30 days after the admission date, for patients discharged from the hospital with a principal diagnosis of heart failure (HF). The hospital-specific risk-standardized mortality rate (RSMR) is calculated as the ratio of the number of "predicted" deaths to the number of "expected" deaths, multiplied by the national unadjusted mortality rate. The "denominator" is the number of deaths expected on the basis of the nation's performance with that hospital's case mix (National Quality Measures).

“Heart failure” refers to the heart's function as a pump. The heart circulates a set amount of blood each time it beats. “heart failure” occurs when the pump is less efficient and cannot circulate the same amount each time, thereby starving the other organs in the body of oxygen ("Heart Attack vs. Heart Failure," 2013).

Heart Failure Readmission

This measure estimates a hospital-level, risk-standardized, all-cause 30-day readmission, defined as readmission for any cause within 30 days from the date of discharge of the admission, for patients discharged from the hospital with a principal discharge diagnosis of heart failure (HF). The "denominator" is the number of readmissions expected on the basis of the nation's performance with that hospital's case mix. The "numerator" of the ratio is the number of readmissions within 30 days predicted on the basis of the hospital's performance with its observed case mix (National Quality Measures).

Pneumonia -30 day Mortality

This measure estimates a hospital-level, risk-standardized mortality rate (RSMR), defined as death from any cause within 30 days after the index admission date, for patients discharged from the hospital with a principal diagnosis of pneumonia. The "denominator" is the number of deaths expected on the basis of the nation's performance with that hospital's case mix. The "numerator" of the ratio component is the number of deaths within 30 days predicted on the basis of the hospital's performance with its observed case mix (National Quality Measures).

Pneumonia Readmission

This measure estimates a hospital-level, risk-standardized, all-cause 30-day readmission, defined as readmission for any cause within 30 days from the date of discharge of the index admission, for patients discharged from the hospital with a principal discharge diagnosis of pneumonia. The "denominator" is the number of readmissions expected on the basis of the nation's performance with that hospital's case mix. The "numerator" of the ratio is the number of readmissions within 30 days predicted on the basis of the hospital's performance with its observed case mix (National Quality Measures).

Control Variables

Because the focus of this research is to analyze the quality performance of hospitals, and hospitals are very complex entities, other healthcare-related factors were incorporated into the regression model to minimize their impact. Past literature indicates that a facility’s quality performance is likely to be influenced by size, type, ownership and case mix (Friesner, et al., 2007; Setia, et al., 2011). Therefore, these confounding variables were controlled for using additional variables found in the Medicare dataset. The number of beds was used to control for facility *size*. Facilities were identified and grouped in one of three categories (General Medical, Specialty, and Critical Access). The resulting classification was used to control for facility *type*. *Ownership* data provided was identified in the dataset as - government, nonprofit and proprietary. To control for *case mix*, the facility’s case mix index (CMI) was retrieved from a third data source ("Case Mix Index," 2013) also provided by the

Centers for Medicare and Medicaid Services. The provider number was once again used to match the index value to the facility.

The CMI is a value calculated by the federal government for each facility and represents their patient acuity. A hospital's CMI signifies the average diagnosis-related group (DRG) relative weight for that hospital. It is calculated by totaling the DRG weights for all Medicare discharges, and dividing that value by the number of discharges. The average CMI is region-specific but nationally is ~1.50 with facilities with lower average acuity receiving lower scores, and higher acuity earning scores above this value. The CMI values for facilities in this study ranged from .577 to 3.754.

As indicated in Figure 4, the Medicare Provider Number and facility name were used to integrate the Medicare Hospital Compare and HIMSS databases matching a given facility with that facility’s quality outcome ratings. The resulting combined dataset contained 3113 facilities with live and operational systems. The SQL code used to accomplish this joining appears in Appendix B.

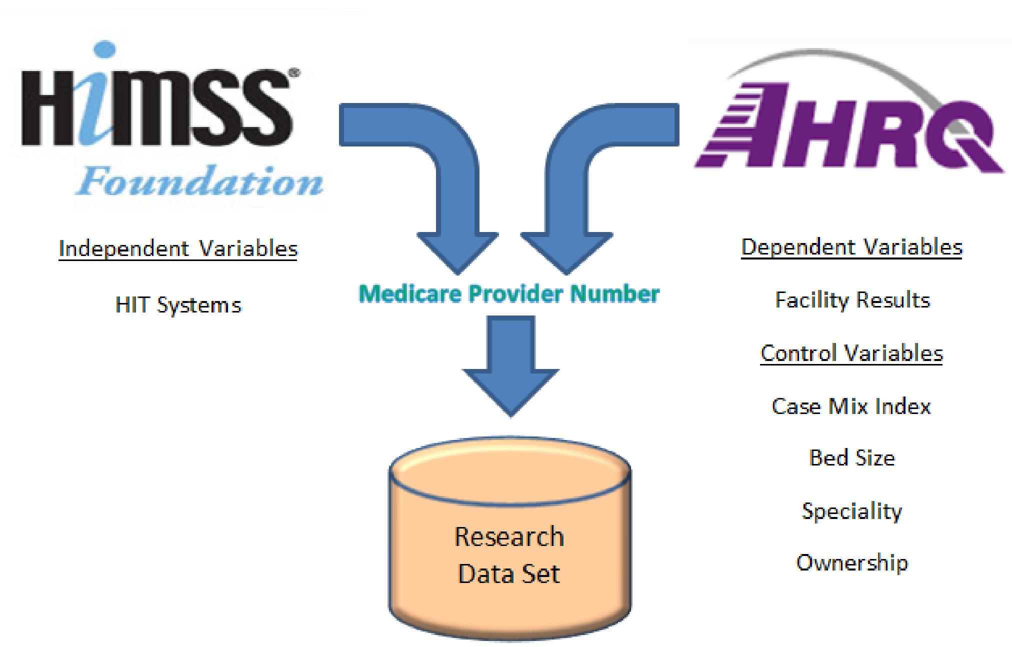

Figure 4. Composition of Research Dataset

Portfolio Definition

All facilities appearing in the research dataset contained multiple HIT systems. The most common clinical system implemented by healthcare facilities was Abstracting (1688 facilities) followed closely by Laboratory Information System (1687 facilities). As these systems interact with each other, synergistic effects may occur. As mentioned earlier, the term synergistic effect refers to an effect arising between two or more entities that produces an effect greater than the sum of their individual effects (Lin, et al., 2006).

Because synergies might be found between any two IT systems, the IT portfolio construct was defined as a combination of two or more clinical IT applications (independent variables). Many applications are present within a given facility. However, although applications may be present, the extent of their use is unknown. Lack of use may stem from incomplete implementation, overlap of functionality with other systems, outdated technology, insufficient user training, user dissatisfaction in system performance, interoperability issues, and legal or regulatory constraints (Burke, et al., 2002). The applications under consideration in this research are currently implemented within healthcare facilities as reported by each facility's chosen healthcare administrator. These systems, as detailed in the HIMSS database, are identified in Table 6.

Data Mining to Narrow the Search Space

Data mining is a relatively new research tool that emerged in the middle of 1990's as a new approach to data analysis. Data mining is the exploration of observational data sets to find unsuspected relationships, and to summarize the data in unique ways that are both understandable and useful to the data owner (Yoo, et al., 2012).

Decision tree classifiers, used in data mining, construct a flowchart-like tree structure in a topdown, recursive, divide-and-conquer, manner. The classifier selects an attribute that best divides the given records into each of the class labels. Selected attributes become nodes in a decision tree. For example (as seen in Figure 6), EDIS is the first attribute (or the root node) selected. The root node is always the most significant attribute to the class. As additional nodes (branches) are added and further divided, they move further away from the root node, they become less significant. The primary advantage to using decision trees is the class-focused visualization of data. This visualization is useful in that it allows users to readily understand the overall structure of data in terms of which attribute(s) have the greatest effects on the class (Yoo, et al., 2012).

The 57 predictor variables (IT applications) are binary (indicating the presence or absence of a particular system) and offered a large number of possible combinations. To deal with the volume of permutations, as well as the facility heterogeneity, data mining techniques were used to narrow the search space. Machine learning software was used for this purpose. A large majority of healthcare facilities fell within the *equal to the national average* parameter leaving a much smaller percentage of facilities with an above or below average rating. This resulted in an unbalanced dataset. The unbalanced dataset caused the datamining software to predict a *national average rating* for all portfolios, as this rating would be a correct determination in a large majority of cases. Therefore to bring the data back into balance, the supervised resampling filter was applied (Khandar & Dani, 2011). Decision trees were then developed to identify combinations of IT systems closely associated with positive results on healthcare quality metrics.

Multiple algorithms were reviewed for this research including BFTree, Random Decision Tree, Random Forest, FT and J48 (Khandar & Dani, 2011). The Best-First decision tree classifier (BFTree) expands the "best" node first. The classifier identifies the "best" node as the node whose split leads to maximum reduction of impurity among all nodes available for splitting. As the name suggests, the Random Decision Tree (RDT) constructs multiple decision trees randomly. While constructing each tree, the algorithm chooses a residual feature arbitrarily at each branch without any purity function check. Random Forest is a learning method where multiple random decision trees are generated, and the mode statistics are used. Random Forests are normally used with data that has been split 70/30 between training and tests sets. FT is the classifier for building 'Functional Trees'. Functional Trees are classification trees that could include logistic regression functions at the interior branches and leaves. The FT algorithm can work with binary and multi-class variables, numerical and nominal attributes as well as missing values. C4.5 is a statistical classifier algorithm based on the earlier ID3 algorithm. This classifier goes back through the tree once it has been created and attempts to remove non-contributing branches replacing them with leaf nodes. J48 is simply an open-source Java implementation of the C4.5 version 8 algorithm. After reviewing the output from each of the available decision tree classifiers, the J48 algorithm was chosen for this research for its level of accuracy in categorizing systems that could be operationalized as IT Portfolios (Table 9). Additionally, C4.5 has been found to be a strong choice for classification when used in conjunction with medical datasets with an accuracy rate greater than 94% (Lavanya, et al., 2011).

The J48 algorithm was applied to each quality metric independently. The resulting output contained a unique decision tree which contained combinations of IT systems visualized as nodes and branches. As discussed in the next chapter, the software produced extensive decisions trees for each of the quality metrics with each branch representing a different combination of IT systems. Those combinations of IT systems associated with *better than average* results were extracted and operationalized as candidate portfolios. Branches of the decision trees containing only a single HIT system were excluded as not meeting the definition of a portfolio (2+ systems). Each remaining candidate potentially contained a synergistic effect between component systems.

Applying Logistic Regression Analysis to Identify Synergies

In the next phase of the approach, the candidate portfolios were subjected to an ordinal logistic regression analysis for testing the synergistic effects among the portfolio components. This was accomplished using the R software environment for statistical computing and graphics in conjunction with the original unbalanced dataset.

The generalized form of the ordinal logistic regression model used to test the portfolios is given by:

$$y = b_0 + \sum_{i=1}^{n} b_i x_i + b_{n+1} \prod_{i=1}^{n} x_i + \sum_{k=1}^{4} b_{n+1+k} z_k$$

where b_0 is the constant and $\sum_{i=1}^{n} b_i x_i$ is the term for the predictor variables when working in isolation. $b_{n+1} \prod_{i=1}^{n} x_i$ represents the interaction of the systems, and identifies the coefficient of the portfolio. The term $\sum_{k=1}^{4} b_{n+1+k} z_k$ represents the four control variables used, and *y* represents the quality outcome (dependent variable) with values *above the national average*, *equal to the national average* or *below the national average*.

To identify if synergies exist, an interaction term was developed. While there are many ways to construct such a term, the most usual, and simplest, is to multiply the independent variables that may be involved by each other, and add that term to the equation (Flom & Strauss, 2003; Harrell, 2001).

Applying the regression formula to the sample decision tree (Figure 5) results in the operational formula:

Heart_Attack_Mortality=EDIS+EDI+Order_Entry+(EDIS*EDI*Order_Entry)+size+type+ownership+CMI

The resulting output from each candidate portfolio was collected for analysis.

CHAPTER 4

RESULTS AND DISCUSSION

Data Mining Results and Analysis

As mentioned earlier, the data mining software produced detailed decisions trees for each of the six quality metrics with each branch of the tree reflecting a unique combination of IT systems. Each branch was associated with one of the quality ratings (better than average, average, below average). Portfolios identified by this algorithm contained two to five member applications. The data mining process identified multiple candidate portfolios for each quality outcome. A sample of one of the decision trees for the Heart Attack Mortality quality performance metric can be seen in Figure 5. Within the decision tree, IT systems are identified as “> 0” or “<= 0”. The greater than zero indicates that the system is present in the portfolio, whereas the less than or equal to zero indicates its absence. In this example, the data mining software indicates the portfolio containing Emergency Department Information System (EDIS), Electronic Data Interchange (EDI) and Order Entry are associated with better than average results. Further, the tree indicates that there are five facilities that contain this portfolio and all of them report this desired rating.

```
EDIS > 0
|  Pharm_Man <= 0
|  |  EDI <= 0: No Different than U.S. National Rate (8.0)
|  |  EDI > 0
|  |  |  Lab_Outreach <= 0
|  |  |  |  Card_Cath Lab <= 0
|  |  |  |  |  In-House_Transcr <= 0
|  |  |  |  |  |  Order_Entry <= 0: No Different than U.S. National Rate (2.0)
|  |  |  |  |  |  Order_Entry > 0: Better than U.S. National Rate (5.0)
```

Figure 5. Sample J48 Decision Tree

The number of candidate portfolios identified by the data mining stage for each quality outcome is detailed in Table 8. A full list of candidate portfolios can be found in Appendix A.

Intersystem Synergies Identified

All healthcare facilities have adopted healthcare information technology to some degree. The manner, extent and results of the interactions between these systems, within a given facility, are varied and difficult to quantify. Whereas facilities attempt to leverage current systems to maximize the benefits of newly introduced HIT, it is clear that not all have been equally successful. Fortunately large datasets allow us to overlook the individual facility anomalies and identify larger industry-wide trends. One method to identify these trends, and to test the extent to which HIT systems within a portfolio are expected to leverage each other's functions and features, is through a statistical regression analysis.

Therefore, a logistic regression was run on each of the candidate portfolios reported in Stage One (data mining). Each regression result returned a list of component systems and their corresponding coefficient. Additionally, the regression results identify the coefficient for combinations of systems. The coefficient indicates to what extent that system (or combination of systems) are associated with the *above the national average* results. Intersystem synergies were identified where the coefficient for the portfolio was greater than the sum of the component coefficients (Flom & Strauss, 2003). The regression result for each portfolio was manually reviewed to identify which of them exhibited synergies. The total number of portfolios reporting synergistic effects for each healthcare metric is detailed in Table 8.

Table 8. Summary of Data Mining and Regression Results

Metric	Decision Tree Leaves	Portfolios Candidates (extracted from D. Trees)	Optimal Portfolios (Regression)
Heart Attack Mortality	92	23	3
Heart Attack Readmission	48	8	3
Heart Failure Mortality	179	49	3
Heart Failure Readmission	173	26	3
Pneumonia 30Day Mortality	202	49	2
Pneumonia Readmission	111	15	2

For example, in the first result for the Heart Attack Mortality metric (portfolio 13 from Appendix A with singularities removed), the Clinical Decision Support System (CDSS) has an independent coefficient which is slightly negative (-0.213957), while the Cardiology Information System (Cardiology_IS) coefficient is also negative (-3.707143). However, when combined into a portfolio, their correlation to *better than average* results is strongly positive

(4.8048062) thereby indicating a synergistic effect. As defined earlier, improved quality of healthcare is achieved through a greater percentage of desired patient outcomes. The regression results indicate that by combining HIT systems as outlined in the following optimal portfolios, these greater percentages can be achieved.

Significance Testing

Determining the presence and extent of synergistic effects within portfolios is a primary outcome from this research. However, the presence of a strong synergistic effect alone is not sufficient as the basis for actionable recommendations. Therefore, in addition to the strength of the synergy, the probability of its presence must also be statistically significant. This significance provides greater confidence that the synergy will be realized by those facilities attempting to duplicate it. To test for probability, the *p* value is included for each portfolio with a level of significance of .05

Analyzing the IT System – Healthcare Metric Link

To more fully understand the intersystem synergies and through what mechanisms they influence quality, it is necessary to investigate the linkages between the portfolio member-systems and the healthcare metric they impact. Some associations are obvious such as the use of a cardiac information system to benefit cardiac patients, and thereby reducing the mortality rate for heart attack patients. However, less obvious are the links between other system/metric combinations such as digital fluoroscopy and pneumonia. In these cases a structured process is needed to help explain the relationship.

The first step to explaining system/metric relationships is to identify direct impacts by the IT system on the quality of care. These impacts are typically a result of the patient or his/her physician directly interacting with the IT system (Fraenkel, et al., 2003), as in the case of the cardiac system example. If no direct relationship is apparent, the second step of the process involves expanding the frame of reference to include how the IT system is implemented in the environment. Answering questions such as, “Who uses this system? How is it used within the hospital? To which diseases/injuries/diagnosis is this system best-suited to assist?” may reveal indirect relationships. Likewise, expanding on the healthcare metric may expose obscured system/metric relationships. To expand on the healthcare metric, consider the diagnoses and conditions that address the given metric, as well as the treatments, therapies and diagnostic tests applied to patients with these diagnoses. As illustrated in Figure 6, by expanding the perspective on both sides of the relationship the logical distance between the IT system and healthcare metric is reduced, thereby increasing the possibility of identifing indirect links.

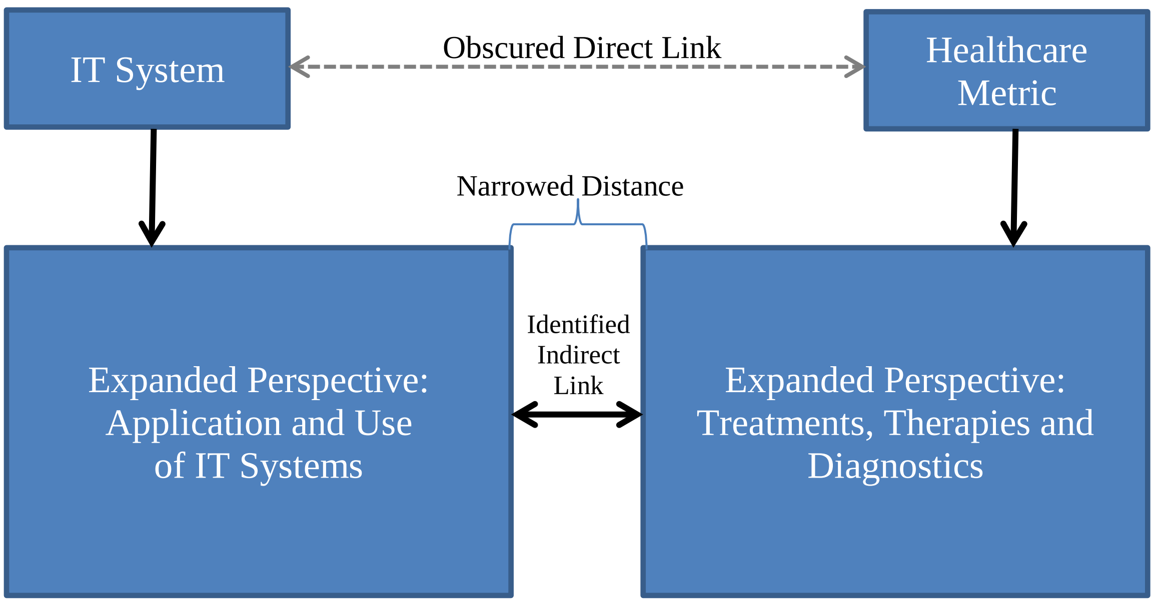

Figure 6. IT System – Healthcare Metric Link

The discussion appearing after each portfolio includes a structured analysis detailing the suspected causes for the synergies. These causes include (1) direct interactions between portfolio members, followed by (2) indirect interactions, or (3) chance or undetermined interactions. The following synergies were identified within the regression results. For clarity, the output for each portfolio tested is limit to those combinations of IT systems demonstrating synergistic effects.

Heart Attack Mortality

Portfolio 13	Estimate	P Value
EDIS	-1.316550	
Pharmacy_Management	-0.665235	
Dictation	-1.661559	
CDSS	-0.213957	
Radiology_MRI	0.044432	

```
Cardiology_IS                                  -3.707143
CDSS:Cardiology_IS                              4.804806    .03895
Radiology_MRI:Cardiology_IS                     4.468318    .04421
EDIS:Pharmacy_Management:Dictation              1.088635    .04285
```

Synergistic Portfolio HAM1
Clinical Decision Support System, Cardiology Information System
Facilities with this portfolio: 847 (74 with *better than average* rating)

A clinical decision support system (CDSS) is an application that healthcare providers use to analyze data in the process of making clinical decisions ("Glossary of Terms and Acronyms Related to e-Health," 2013). A CDSS is an adaptation of the decision support system used most commonly to support business and management decision-making. CDSS assist physicians in diagnosis and treatment of patients. A CDSS can provide additional confidence in a diagnosis, or recommend further investigation if the diagnosis is uncertain. Applying a CDSS developed using evidence-based guidelines for cardiac patients in primary care could have a significant positive influence on patient care (Toth-Pal, et al., 2008). The cardiology information system (CIS) allows physicians to access their patients' cardiac histories as well as results when and where they are needed ("Glossary of Terms and Acronyms Related to e-Health," 2013). Both of these systems allow physicians to access data remotely thereby offering the opportunity to consult with colleagues at different facilities in real-time.

Synergistic Portfolio HAM2
Radiology: Medical Resonance Imaging, Cardiology Information System (CIS)
Facilities with this portfolio: 834 (74 with *better than average* rating)

The noninvasive medical diagnostic technique known as Medical Resonance Imaging (MRI), analyses the body’s absorption of high-frequency radio waves ("Glossary of Terms and Acronyms Related to e-Health," 2013). This technique is commonly used for diagnosis and treatment of cancer. An MRI system may enhance the performance of a CIS by providing the necessary imaging to monitor and manage pacemaker recipients. Cardiovascular imaging using an MRI is used extensively during pacemaker implantation and is a required component to offer the coronary angiography service. However, recent studies indicate that computerized tomography (CT) scans may be safer (Harvard, 2012). Additionally, medical resonance imaging is an instrumental tool in treating heart disease. This technique obtains information about the heart as it is beating, creating images of the heart throughout it pumping cycle (Dungu, et al., 2013).

Synergistic Portfolio HAM3
Emergency Department Information System, Pharmacy Management, Dictation
Facilities with this portfolio: 1211 (62 with *better than average* rating)

Emergency Department Information Systems (EDIS) are designed to automate and streamline the department's workflow and deliver patients a more efficient and improved quality of care ("Glossary of Terms and Acronyms Related to e-Health," 2013). These systems are specifically designed to meet the unique needs of emergency room patients and physicians. The hospital's first HIT system that impacts a patient experiencing a heart attack is often their EDIS. The EDIS has become an effective tool for supporting physicians with better decision support and helping nurses to more efficiently document the care and treatment of patients (Banks, 2011). Pharmacy management systems primarily manage data with respect to the dispensing of prescriptions. However, they also control inventory, assist with the billing of claims, and ensure compliance with laws and regulations ("Glossary of Terms and Acronyms Related to e-Health," 2013). The pharmacist plays a vital role in treating heart failure patients. The timely and accurate administration of medications such hydralazine, isosorbide dinitrate, and beta blockers have been shown to improve survival rates (Cohn, et al., 1986). A hospital's dictation system allows physicians to create voice recordings. These recordings allow hands-free documentation of procedures in real-time as well as providing out-of-station physicians with the ability to leave patient instructions and orders ("Glossary of Terms and Acronyms Related to e-Health," 2013). The effect of a dictation system on heart attack mortality appears to be indirect. In the busy emergency room, all three of these systems may play a pivotal role in increasing the speed of care delivered to the patient, which in turn may impact quality outcomes.

Heart Attack Readmission

Portfolio 4	Estimate	P Value
OR_Scheduling	-0.767901	
Lab_Outreach Services	-11.043843	
Dictation with Speech Recognition	-5.556865	
OR_Scheduling:Lab_Outreach	15.285874	.04559
OR_Scheduling:Dictation_SR	8.091687	.03939

```
OR_Scheduling:Lab_Outreach:Dictation_SR          3.208897    .04984
```

Synergistic Portfolio HAR1
Operating Room Scheduling, Laboratory Outreach Services
Facilities with this portfolio: 265 (18 with *better than average* rating)

An operating room scheduling system provides physicians and administrators with information on each surgical procedure that is planned, currently underway, or has been completed. The system also assists with material management, material requirement planning, and pre-admission consultations ("Glossary of Terms and Acronyms Related to e-Health," 2013). It also offers an opportunity to record clinical notes for procedures, sterilization management, and transcription. Many heart attack patients require surgical procedures. The OR scheduling system assists by ensuring appropriate anesthesia provider expertise, and equipment availability at each anesthetizing location (Dexter & Thompson, 2001). Laboratory outreach is a service offered by facilities where a facility's laboratory services are made available to outpatients as well as patients of other facilities and physicians ("Glossary of Terms and Acronyms Related to e-Health," 2013). However, while financial benefits are clear, laboratory outreach has not been traditionally associated with improved quality of care. Neither a direct or indirect connection is apparent between laboratory outreach systems and the heart attack mortality quality metric. Therefore, the impact of this system is uncertain, but there may be a tie between the patients who receive laboratory services, and the results of those tests necessitating operative services.

Synergistic Portfolio HAR2
Operating Room Scheduling, Dictation with Speech Recognition
Facilities with this portfolio: 458 (16 with *better than average* rating)

As mentioned earlier, a dictation system allows physicians to record patient instructions. However, an enhanced dictation system equipped with speech recognition allows the recordings to be converted into a digital format and easily imported into the computer as text ("Glossary of Terms and Acronyms Related to e-Health," 2013). Conversely, the speech functions also allows patient statistics such date of birth, medical history and patient instructions to be transferred from the computer onto the recording. The benefits offered by a dictation with speech recognition system may be indirect. Radiologists, among others, are frequent users of this type of technology which improves workflow and expedites reports

(Chen, et al., 2009). Improving the radiology department's performance may then improve care to heart attack patients.

Synergistic Portfolio HAR3
Operating Room Scheduling, Laboratory Outreach Services, Dictation with Speech Recognition
Facilities with this portfolio: 130 (16 with *better than average* rating)

All three member systems have been introduced in previous portfolios. However, this portfolio has been adopted by relatively few facilities. In this combination of systems, we have effectively a merger of the previous two portfolios. The synergistic effects would be expected as laboratory outreach services and dictation with speech recognition have both demonstrated a positive synergy when associated with an operating room scheduling system.

Heart Failure Mortality

Portfolio 6	Estimate	P Value
Order_Entry	0.026469	
Chart_Track	-0.703990	
Laboratory_IS	0.185730	
Microbiology	-1.446710	
Order_Entry:Chart_Tracking	1.591157	.04620
Laboratory_IS:Microbiology	1.661938	.02958

Portfolio 29	Estimate	P Value
Cardiology_Cath.Lab	-1.016270	
Pharmacy_Management	-0.152552	
Chart_Tracking	0.160954	
Anatomical_Pathology	0.151822	
Cardiology_Cath.Lab:Pharmacy_Management: Chart_Tracking:Anatomical_Pathology	1.592765	.03695

Synergistic Portfolio HFM1
Order Entry, Chart Tracking
Facilities with this portfolio: 1512 (86 with *better than average* rating)

An order entry system is a component of an electronic medical records system which allows patient orders to be entered directly into the electronic record at the point of service. It also provides a mechanism to communicate those orders to external parties such as pharmacies and laboratories. The use of order entry systems with decision support have been shown to improve the quality of care for patients with chronic conditions such as heart failure (Simon, et al., 2007). A chart tracking system is also usually a module of a larger electronic medical records (EMR) management tool that is designed to manage the patient's paper-based records. Chart tracking systems can significantly streamline the processes and reduce the workload associated with records management. Chart tracking systems offer a secondary effect on heart failure. Chart tracking systems provide the framework which allows the other HIT systems to access and share data quickly thereby facilitating timely treatment (Merriman, et al., 1993). As subcomponents of a common EMR, these systems are closely related, and therefore lend themselves to leveraging the other's benefits.

Synergistic Portfolio HFM2
Laboratory Information Systems, Microbiology
Facilities with this portfolio: 1514 (180 with *better than average* rating)

Care givers use laboratory information systems (LIS) to manage an assortment of inpatient and outpatient medical testing, including hematology, chemistry, oncology, immunology and microbiology ("Glossary of Terms and Acronyms Related to e-Health," 2013). As a specialized LIS, the microbiology system is designed to seamlessly integrate into the microbiology testing workflow enabling laboratories to achieve standardized, precise, and consistent results while maximizing lab efficiency ("Glossary of Terms and Acronyms Related to e-Health," 2013). Physicians treating patients for heart failure utilize microbiology systems to identify infections which place additional stress on the heart. Microbiology systems also are instrumental in diagnosing and treating cardiac conditions such as infective endocarditis where blood borne bacteria infect cardiac tissue (Joshi, 2011).

Synergistic Portfolio HFM3
Cardiology: Catheterization Laboratory, Pharmacy Management, Chart Tracking, Anatomical Pathology
Facilities with this portfolio: 463 (98 with *better than average* rating)

The Cardiology: Catheterization Laboratory system collects, stores, maintains and protects still images and video created during cardiac catheterization procedures ("Glossary of Terms and Acronyms Related to e-Health," 2013). Naturally, cardiology systems are designed to promote the care of cardiac patients. However, anatomical pathology are not as directly associated with cardiac care. These systems can provide diagnosis of heart disease through the microscopic examination of tissues secured through biopsies or removal during surgery, and provide benefits indirectly through physician education from autopsy reports (Heatley, 2010).

Heart Failure Readmission

Portfolio 4	Estimate	P Value
Blood_Bank	0.123467	
Microbiology	-0.025624	
Obstetrical_Systems	-0.558120	
Radiology_MRI	-0.143150	
Blood_Bank:Microbiology: Obstetrical_Systems:Radiology_MRI	2.672228	.04854

Portfolio 23	Estimate	
Blood_Bank	0.048369	
Microbiology	0.127110	
Consumer_Portal	1.142723	
Anatomical_Pathology	1.627532	
CPOE	0.373514	
Blood_Bank:Consumer_Portal:CPOE	3.713268	.04541
Microbiology:Anatomical_Pathology:CPOE	4.281513	.02237

Synergistic Portfolio HFR1
Blood Bank, Microbiology, Obstetrical Systems, Radiology: Medical Resonance Imaging
Facilities with this portfolio: 820 (76 with *better than average* rating)

A blood bank information system is a multi-module application that assists in areas such as donor recruitment, blood collection, inventory control, donor testing, shipping, transfusion, and billing ("Glossary of Terms and Acronyms Related to e-Health," 2013). Patients arriving in the emergency room who have experienced significant blood loss or surgical patients needing infusions are at risk for heart failure. The drop in blood volume (and subsequently pressure) places additional stress on the heart ("Wellness Information," 2013). An obstetrical information system receives analog information from various monitors which is digitized before being input. OB systems typically have admission, transfer, edit, and discharge functions ("Glossary of Terms and Acronyms Related to e-Health," 2013). OB systems may have a secondary effect on the heart failure metric as pregnancy can create high-blood pressure in some women thereby increasing their risk for heart failure, and childbirth can cause some women to experience cardiac episodes (Sartain, et al., 2012). This portfolio is rather unique for two reasons. First, it is one of only two portfolios that incorporate four IT systems; and second, these systems represent four distinct departments within the healthcare facility.

Synergistic Portfolio HFR2
Blood Bank, Consumer Portal, Computerized Physician Order Entry
Facilities with this portfolio: 120 (14 with *better than average* rating)

A consumer portal provides patients with direct access to their personal information regarding their health plan coverage, medical history and treatment plans, as well as offering patient services such as appointment scheduling and prescription refill ordering ("Glossary of Terms and Acronyms Related to e-Health," 2013). A computerized physician order entry system (CPOE) allows entering of medication orders or other physician instructions electronically instead of on paper charts. The use of a CPOE system can help reduce errors related to illegible handwriting or transcription of medication orders ("Glossary of Terms and Acronyms Related to e-Health," 2013). This candidate portfolio was found in the fewest facilities in this study. The beneficial relationship between the blood bank and heart failure patients has been outlined in earlier portfolios. However, a recent study has indicated that the use of CPOE systems also reduces mortality and complications from heart failure (Jones, et al., 2011). A consumer portal may have a secondary effect by allowing patients to monitor their test results such as blood pressure and cholesterol levels, as well as review physician's at-home care instructions after a hospital stay (Ammenwerth, et al., 2012). Access to this information may improve recovery and reduce the occurrence of readmission.

Synergistic Portfolio HFR3
Microbiology, Anatomical Pathology, Computerized Physician Order Entry
Facilities with this portfolio: 336 (18 with *better than average* rating)

An anatomical pathology laboratory information system (APLIS) logs specimens, records microscopic findings, regulates laboratory workflow, formulates reports, distributes them to the intended recipients throughout the healthcare system, and supports quality assurance measures. They also support asset tracking and digital imaging ("Glossary of Terms and Acronyms Related to e-Health," 2013). All three of these systems appear in other portfolios tied to the heart failure readmission metric further strengthening their ties improved quality.

Pneumonia 30 day Death

Portfolio 1	Estimate	P Value
Dictation	-0.314298	
Abstracting	-0.257044	
Radiology_Angiography	1.931669	
Dictation:Abstracting	0.886240	.04914

<u>Portfolio 22</u>	Estimate	
Radiology_DM	-0.040562	
Radiology_Nuclear	0.140742	
Operating_Room_Pre	0.770414	
OR_Scheduling	0.055803	
Radiology_DM:Operating_Room_Pre:OR_Scheduling	3.855601	.04735

<u>Synergistic Portfolio PD1</u>
Dictation, Abstracting
Facilities with this portfolio: 1570 (182 with *better than average* rating)

A coding and abstracting information system efficiently summarizes clinical data. The abstracting process supports later activities such as coding and reimbursement, quality improvement initiatives, billing audits, and clinical research ("Glossary of Terms and Acronyms Related to e-Health," 2013). This two member-system portfolio was the most commonly found at the facilities under review. Interestingly it is also the only portfolio to include an abstracting information system. The benefits to pneumonia patients appear to be indirect. Both of these systems help expedite the administration function, improve productivity and allow care providers to devote more of their time and attention to providing care to the patient (Lorenzoni, et al., 1999).

<u>Synergistic Portfolio PD2</u>
Radiology: Digital Mammography, Operating Room: Pre-Operative, Operating Room Scheduling
Facilities with this portfolio: 660 (106 with *better than average* rating)

A digital mammography system collects, stores, manages and disseminates x-ray images created during breast examinations. The resulting images are analyzed for abnormalities which may indicate cancerous tissue ("Glossary of Terms and Acronyms Related to e-Health," 2013). Rather than a direct impact on pneumonia patients, a digital mammography system is a marker for facilities that have advanced radiology departments. Other radiological tools found in these departments such as CT and MRI equipment would offer more direct benefits to the diagnosis and treatment of pneumonia (Hardy, 2012). The pre-operative system assists anesthesiologists in pre-operative patient assessment and application of anesthesia. Pneumonia is of grave concern for patients recovering from surgery - particularly in the elderly (Allou, et al., 2010). Maximizing the quality of care during all stages of the surgical process may reduce the occurrence of pneumonia and thereby affect this metric.

Pneumonia Readmission

Portfolio 3	Estimate	P Value
Radiology_DR	-0.883888	
Dictation	-0.646310	
Radiology_DF	1.330881	
Operating_Room_Post	-1.059171	
Radiology_DR:Dictation	0.375184	.03956
Radiology_DR:Radiology_DF:Operating_Room_Post	2.447464	.04881

Synergistic Portfolio PR1
Radiology: Digital Radiography, Dictation
Facilities with this portfolio: 1297 (46 with *better than average* rating)

A digital radiography system offers advancement over the traditional film x-ray. Images are held digitally and are available immediately ("Glossary of Terms and Acronyms Related to e-Health," 2013). This eliminates the need to wait for film development, and allows physicians to more quickly review and diagnose patients. Since a chest x-ray is the primary means by which physicians diagnose pneumonia (Majeski, 2013), any tool which improves upon the functionality or speed of this treatment would positively affect a facility's performance in the frequency of patients readmitted because of pneumonia.

Synergistic Portfolio PR2
Radiology: Digital Radiography, Radiology: Digital Fluoroscopy, Operating Room: Post-Operative
Facilities with this portfolio: 940 (40 with *better than average* rating)

Digital fluoroscopy is a digital x-ray imaging system similar to digital radiography; however, the images are dynamic. Digital fluoroscopy is a form of x-ray that allows physicians to inspect deep tissues in the body in real-time on a computer monitor ("Glossary of Terms and Acronyms Related to e-Health," 2013). It provides detailed images of the function and structure of areas like the lungs, the liver, the heart and kidneys. Digital fluoroscopy is used extensively in the diagnosis and treatment of lung cancer as the technology can quantify the number of tumors and their size. These patients with weakened immune systems and reduced lung function are particularly susceptible to pneumonia (McNair, et al., 2012). A post-operative care system can give consultative and decision support to surgical recovery staff with the goal of reducing surgical site infections, heart attacks, blood clots, and postoperative pneumonia (Allou, et al., 2010). Once again, this portfolio contains systems that either directly relate to either the diagnosis or prevention of pneumonia, or to the treatment of an antecedent.

Negative Synergies Identified

Interestingly, synergistic effects can affect patient quality outcomes in both a positive as well as negative manner. While most portfolio coefficients revealed little to no synergistic effects, and several portfolios (as detailed above) indicated a positive synergistic effect, four portfolios reported a negative impact on quality. Three of these portfolios apply to the heart attack readmission metric, and the fourth deals with heart failure readmission.

Heart Attack Readmission

Portfolio 1	Estimate	P Value
Operating_Room_Scheduling	3.044564	
Radiology_DR	2.808544	
EDI	2.752098	
CPOE	1.803123	
Operating_Room_Scheduling:EDI	-3.535674	.04501
Operating_Room_Scheduling:CPOE	-4.989675	.05021
Radiology_DR:CPOE	-8.012095	.04288

In these results we see that the *operating room scheduling, radiology: digital radiography, electronic data interchange (EDI)*, and *computerized physician order entry (CPOE)* have been combined into a single portfolio. An EDI system allows the transfer of information between two disparate systems of networks ("Glossary of Terms and Acronyms Related to e-Health," 2013). These tools are often used to allow legacy within a facility to communicate or allow the transfer of patient records between facilities. Each of these systems have a moderately positive correlation with better than average results. However, when *operating room scheduling* is joined with *EDI* or *CPOE* the combined scores are significantly negative. Likewise, when *radiology: digital radiography* is joined with *CPOE,* we see an even greater change to the results. Since most of these systems appear in one or more of the candidate portfolios, we cannot simply dismiss the systems as offering little value in a portfolio environment. However, it is clear that for at least the heart attack readmission quality metric, intersystem dynamics are present which may be hampering quality.

Heart Failure Readmission

Portfolio 23	Estimate	P Value
Blood_Bank	0.048369	
Microbiology	0.127110	
Consumer_Portal	1.142723	
CPOE	0.373514	
Blood_Bank:Microbiology:Consumer_Portal:CPOE	-4.927736	.03785

The heart failure readmission results above reveal that the *blood bank*, *microbiology*, *consumer portal* and *CPOE* systems have nearly a neutral influence on quality. However, when all four systems are combined, they offer a strong negative impact. The commonality between these two examples is the inclusion of CPOE in the portfolios. As documented by Koppel, et al. (2005), CPOE systems produce the opportunity to introduce medical errors into the system, and thus negatively impact quality.

The causes of these negative effects are not fully apparent. However, what is clear from these results is that the introduction of additional IT systems into a healthcare environment may not always prove to be advantageous, and in some cases may result in a detriment to patients and the organization. This finding directly supports the Yu and Houston (2007) contention discussed earlier that IT adoption is not a strong predictor of quality performance.

Alternate Algorithms Examined

As mentioned in the previous chapter, although the J48 algorithm was used to narrow the search space during the decision tree classification phase of the approach, multiple algorithms were tested to determine which one identified the portfolios with the strongest synergies with the high probabilities. J48 is an open source Java implementation of the C4.5 algorithm. C4.5 in turn, is a descendant of the CLS and ID3 algorithms. Like its forerunners, C4.5 generates classifiers expressed as decision trees, although it can also construct classifiers in more comprehensible rule set format. C4.5 uses two empirical criteria to rank possible tests: information gain, which minimizes the total disorder, and the default gain ratio that divides information gain by the information provided by the test outcomes. The *k*-means algorithm is an iterative process to partition a dataset into a predetermined number of clusters, known as k. Techniques for selecting the center of these clusters include sampling at random from the dataset, and setting them as the solution of clustering a small subset of the data. Support vector machines offer one of the most accurate and robust approaches among all well-known algorithms. Its sound theoretical foundation requires only 12 data points for training, and it is effective regardless of the number of dimensions.

As discussed earlier, the Best First Tree, Random Tree, Random Forest, and Functional Tree algorithms were also used to identify candidate portfolios. These algorithms were determined by Wu, et al. (2008) as commonly used classifiers for data mining. To ensure fairness, each algorithm was applied to the results for the same metric (Heart Attack Death) and their output was compared. All algorithms scored well by classifying at least 97% of systems correctly. However, there is significant difference in the size of their decision trees and their resulting portfolios. The results can be seen in Table 9.

Table 9. Alternate Algorithm Results

Algorithm	Percent of Systems Correctly Classified	Size of Tree	Number of Portfolios
J48	98.6367%	183	23
Best First Tree (BFTree)	97.0688%	161	23
Random Tree	97.7955%	373	42
Random Forest	99.7273%	N/A	0
Functional Tree (FT)	97.0007%	N/A	0

Each algorithm generated output for each metric. However, only J48, BFTree and Random Tree algorithms generated a tree which identified combinations of HIT systems that could be operationalized as portfolios, with J48 having the lowest error rate. The Random Forest and FT algorithm's output did not lend itself to this type of analysis. A sample of the output from these algorithms is offered in Table 10.

Since portfolios could be generated from the BFTree and Random Tree decisions trees, these portfolios were extracted and analyzed for accuracy. In all instances, the Random Tree classifier generated more candidate portfolios than the BFTree or J48 classifiers. The number of portfolios extracted from each decision tree is detailed in Table 11.

Table 10. Nonoperational Output from Algorithms

<table>
<tr><th>Algorithm</th><th>Sample Output</th></tr>
<tr><td>Random Forest</td><td>Random forest of 10 trees, each constructed while considering 6 random features.

Out of bag error: 0.0723</td></tr>
<tr><td>Functional Tree (FT)</td><td>FT tree

N2#1 <= 0.451618
| N1#2 <= 0.662295
| | N2#3 <= 0.413524
| | | N2#4 <= 0.008513
| | | | N0#5 <= 0.439508: Class=1
| | | | N0#5 > 0.439508
| | | | | N0#7 <= 0.716196
| | | | | | N0#8 <= 0.650838: Class=1
| | | | | | N0#8 > 0.650838: Class=0
| | | | | N0#7 > 0.716196
| | | | | | N0#11 <= 0.708932: Class=1
| | | | | | N0#11 > 0.708932</td></tr>
</table>

Table 11. Number of Candidate Portfolios by Alternate Classifiers

Alternate Classifier	Quality Metric	Candidate Portfolios	Overlap with J48
BFTree	Heart Attack Mortality	23	20
	Heart Attack Readmission	5	3
	Heart Failure Mortality	40	31
	Heart Failure Readmission	23	18
	Pneumonia 30 Day Mortality	43	34
	Pneumonia 30 Day Readmission	13	10
Random Tree	Heart Attack Mortality	42	19
	Heart Attack Readmission	14	6
	Heart Failure Mortality	88	35
	Heart Failure Readmission	45	22
	Pneumonia 30 Day Mortality	82	40
	Pneumonia 30 Day Readmission	21	12

Comparing Algorithm Results

The candidate portfolios identified by the BFTree and Random Tree classifiers ranged in size between two and four member systems, and contained significant overlap with the J48 classifier (Table 11). Where BFTree and Random Tree diverged from J48, these candidate portfolios were reviewed to determine if additional synergies could be identified.

BFTree

BFTree identified 6 out of the 16 optimal portfolios identified by the J48 classifier. In addition, it identified four synergies not reported by J48. However, the synergies uniquely identified by BFTree were weaker than those identified by J48.

Random Tree

The Random Tree classifier generated the largest number of candidate portfolios for each quality metric. However, it had the smallest percentage of overlap with J48, and none of the candidate portfolios uniquely identified by this algorithm contained a strong synergistic effect.

The evaluation of the results from the data mining process provided observations into their suitability for this approach. Of the classifiers investigated in this research, none of them generated perfect results. It is clear that a single classifier may not be sufficient to identify every portfolio that demonstrates a synergistic effect. However, with the millions of possible permutations available with 57 independent variables, and with synergistic effects of all sizes, the objective to applying this proposed approach would be to identify the strongest positive synergistic effects with the highest probability.

Alternate Approaches

To support the viability of this approach's portfolio detection and testing methodology, besides additional classifiers, the approach was attempted using cluster analysis as the mechanism for portfolio detection in place of data mining and decision tree analysis.

k-means Cluster Analysis

The *k*-means procedure attempts to identify comparatively homogeneous groups of variables based on predefined characteristics. *K*-means uses an algorithm designed to handle large numbers of cases, and requires the user to initially specify the number of clusters. For the Heart Attack Death data, the cluster analysis was run using 3 clusters, one for each of the three possible metric ratings (better than average, average, worse than average). The Classes to Clusters Evaluation method was used as well as the Euclidean Distance Function. The results were calculated using 10 starting seeds, and a maximum of 500 iterations. A value was returned for HIT system reflecting its association with each cluster. The IT systems with the greatest estimates were operationalized as a portfolio for further testing.

Heart Attack Death

```
Cluster: Better than National Average
=======================================
                               Centroid
Radiology_CT                    0.9938
Radiology_CR                    0.9896
Radiology_MRI                   0.9896
Radiology_Nuclear               0.9896
```

Portfolio K1
Radiology - Computerized Tomography, Radiology - Computed Radiography,
Radiology - Magnetic Resonance Imaging, Radiology - Nuclear Medicine
Facilities with this Portfolio: 1398

The *k*-means algorithm identified the HIT systems most correlated with the Better than the National Average quality rating to be all from the Radiology Department. Each of the facilities was assigned to one of the three clusters. However, unfortunately as noted in the output below, this clustering analysis reported a high percentage of incorrect cluster assignments (47.1%).

```
   0   1   2  <-- assigned to cluster
   3  25  18 | Better than U.S. National Rate
 202 447 748 | No Different than U.S. National Rate
   3  10  11 | Worse than U.S. National Rate

Incorrectly clustered instances :   691.0  47.1029 %
```

To determine if this reflects synergistic effects, a logistic regression was completed on these systems. The results of this regression appear below, and indicate that there is a synergistic effect between the three-member portfolio of Radiology - Computed Radiography, Radiology - Magnetic Resonance Imaging, Radiology - Nuclear Medicine. While Radiology - Computerized Tomography received the highest centroid value, the addition of this system to the portfolio greatly reduces its correlation to better than average results.

```
                                                               Estimate
Radiology_CR                                                   0.047957
Radiology_CT                                                   0.269921
Radiology_MRI                                                 -0.078972
Radiology_Nuclear                                             -0.370271
Radiology_CR:Radiology_CT                                      1.786272
Radiology_CR:Radiology_MRI                                    -0.130293
Radiology_CT:Radiology_MRI                                    -0.108119
Radiology_CR:Radiology_Nuclear                                 0.626534
Radiology_CT:Radiology_Nuclear                                -0.154795
Radiology_MRI:Radiology_Nuclear                               -0.462585
Radiology_CR:Radiology_CT:Radiology_MRI                       -1.925411
Radiology_CR:Radiology_CT:Radiology_Nuclear                   -2.056134
Radiology_CR:Radiology_MRI:Radiology_Nuclear                   3.035039
Radiology_CT:Radiology_MRI:Radiology_Nuclear                   1.466706
Radiology_CR:Radiology_CT:Radiology_MRI:Radiology_Nuclear -2.204724
```

Expectation Maximization (EM) Cluster Analysis

The Expectation–Maximization (EM) algorithm is a normal mixture model, which can be used to cluster continuous data and to estimate the cluster's density. EM is useful as a flexible and powerful method to the modeling and clustering of data observed from random phenomena. EM is similar to *k*-means with two important distinctions: First, instead of assigning cases or observations to clusters to maximize the differences in means for continuous variables, the goal of the EM clustering algorithm is to maximize the overall probability or likelihood of the data. Second, unlike traditional *k*-means clustering, the EM algorithm can be applied to both continuous and categorical variables.

To further investigate cluster analysis as an alternative method to portfolio identification, a cluster analysis was completed using the EM algorithm. Once again, the Classes to Clusters Evaluation method was used incorporating the same number of clusters (3), one for each of the metric ratings. Additionally, the number of seeds and maximum iterations were set to 100, and the minimum standard deviation was $1.0e^{-6}$.

For each cluster, the EM analysis returned a mean and standard deviation for each of the HIT systems in the dataset. The results included a range of means from 0 to 1, and standard deviations ranging from .0053 to .4999. A portion of the results from the EM analysis containing the systems with the highest means are shown below. These results were similar to the *k*-means analysis with the addition of the Chart Deficiencies system. These systems were operationalized as a portfolio.

```
Cluster: Better than National Average
Attribute             mean    std. dev.
==========================================
Chart_Def               1     .0053
Radiology_CT            1     .3144
Radiology_MRI           1     .3321
Radiology_Nuclear       1     .3403
Radiology_CR            1     .3454
```

<u>Portfolio E1</u>
Chart Deficiency, Radiology - Computerized Tomography, Radiology - Computed Radiography, Radiology - Magnetic Resonance Imaging, Radiology - Nuclear Medicine
Facilities with this Portfolio: 1315

Most of the HIT systems that the EM algorithm identified as being most correlated with the Better than the National Average quality rating were also found in the Radiology Department. Once again, each of the facilities was assigned to one of the three clusters. However, the EM algorithm fared worse with a higher percentage of incorrect assignments (49.5%).

```
   0   1   2  <-- assigned to cluster
  14   7  25 | Better than U.S. National Rate
 336 341 720 | No Different than U.S. National Rate
   9   8   7 | Worse than U.S. National Rate

Incorrectly clustered instances :   725.0  49.4206 %
```

To determine EM's accuracy in recommending portfolios containing synergistic effects, a logistic regression was completed on these systems. The results of this regression appear below, but do not indicate that there is a synergistic effect in any combination of member systems. Additionally, three of the coefficients were undefined due to singularities.

	Estimate
Chart_Def	0.8336985
Radiology_CT	0.5464006
Radiology_MRI	1.7372548
Radiology_Nuclear	3.7201014
Chart_Def:Radiology_CT	1.4906673

```
Chart_Def:Radiology_MRI                                          -2.0253372
Radiology_CT:Radiology_MRI                                       -1.9560140
Chart_Def:Radiology_Nuclear                                      -3.9295875
Radiology_CT:Radiology_Nuclear                                   -2.0171279
Radiology_MRI:Radiology_Nuclear                                  -1.4129247
Chart_Def:Radiology_CT:Radiology_MRI                                     NA
Chart_Def:Radiology_CT:Radiology_Nuclear                                 NA
Chart_Def:Radiology_MRI:Radiology_Nuclear                         3.6844179
Radiology_CT:Radiology_MRI:Radiology_Nuclear                     -0.2324194
Chart_Def:Radiology_CT:Radiology_MRI:Radiology_Nuclear                   NA
```

It does not appear that cluster analysis would make a suitable alternative to classification using decision trees for narrowing the search space and portfolio recommendation. Data mining's decision tree output provided an extensive list of candidate portfolios; many of which were later identified to contain synergistic effects. Although the decision trees also identified portfolios which did not result in synergies, the output was much more comprehensive and proved to be a good starting point from which to launch the regression analysis in Step 2 of this approach. The clustering analysis provided only a list of the independent variables and their relationship to each cluster. It did not identify groups of systems operationalized as portfolios. Therefore, using clustering analysis would only allow a small number of portfolios to be detected if testing was completed on the top-scoring systems.

Stepwise Regression

To identify alternate and possibly superior method to identify candidate portfolios outlined in this approach, stepwise regression was examined. Stepwise regression is a statistical approach to building a model by adding or removing variables based on their estimated coefficients. Once a variable is added or deleted in the forward addition or backward removal methods respectively, the action cannot be reversed at a later stage. This approach is helpful in developing a model with a large selection of independent variables. However, stepwise regression suffers from the concern that the tests are biased since each iterative test is based on the same dataset. To counter this, the model should be trained on one dataset and tested against another. If only a single data source is available, the model should be trained against a portion of it and tested against the remaining data. Stepwise regression was used to isolate and identify intersystem synergies. All 57 independent and four control variables were included in the regression.

The results in Table 12 are a partial output from a stepwise regression run in the R Software Environment for Statistical Computing and Graphics on the Heart Attack Mortality portfolio of EDIS, Pharmacy Management, Dictation, CDSS, Radiology_MRI, and Cardiology Information System.

Table 12. Step-wise regression results

System	Coefficient
EDIS	1.159816
Pharmacy Management	-0.959512
Dictation	-0.286406
CDSS	0.668339
Radiology MRI	-0.039292
Cardiology Information System	0.341806
EDIS:Pharm_Man:CDSS:Radiology_MRI	1.957803
EDIS:Pharm_Man:Dictation:Card_IS	6.349063
EDIS:Pharm_Man:Dictation:Radiology_MRI	N/A
EDIS:Dictation:CDSS:Card_IS	N/A
EDIS:Pharm_Man:Dictation:Radiology_MRI:Card_IS	N/A

These results of the stepwise regression include an Akaike Information Criterion (AIC) value of 681.46, and do indicate the presence of some synergies, and may prove to be a suitable alternative to ordinal logistic regression used for this research. However, as indicated by some results in Table 12, the full output from the analysis indicated a large portion of coefficients which could not be defined due to singularities. The full stepwise regression output can be found in Appendix C.

Size and Distribution of Portfolios

The goal of this research was to apply a unique approach to identify optimal portfolios to promote healthcare. The approach introduced and outlined in this research, narrowed the search space with data mining techniques, and then applied logistic regression analysis to confirm the presence of synergistic effects. Those systems demonstrating synergistic effects were operationalized as portfolios. The application of this proposed approach revealed 16 optimal portfolios. These portfolios contained two, three or four member systems. Figure 6 identifies the frequency of these portfolios. It appears that as the portfolio size (number of member systems) increases, the less likely it is that it will be optimal. As a portfolio increases its member systems, the number of intersystem relationships increases exponentially and therefore the intersystem dynamics become more complex. It appears that as the complexity of a portfolio increases, the synergies may become mitigated to some extent.

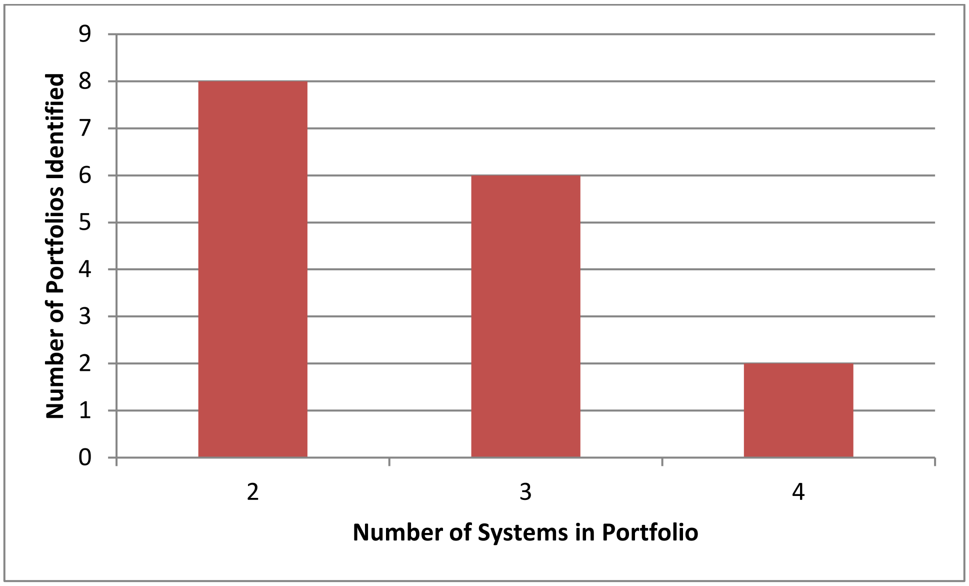

Figure 7. Number and Size of Candidate Portfolios

HIT System Specialization

As discussed earlier, hospitals, clinics and other healthcare providers adopt information technology for differing reasons. One of these reasons is to improve quality. While the collection of candidate portfolios represents nearly 30 unique information technology systems, it appears that IT systems offer varying degrees of impact on specific healthcare metrics. Therefore, quality cannot be examined holistically, but rather it requires a more targeted examination.

An information system such as *dictation* appears to offer widespread benefits as it appears in portfolios addressing multiple quality metrics. However, the *cardiology information system* is prevalent in the portfolios found to be effective in combating heart attack mortality, but is not present in any portfolios addressing pneumonia. While a cardiology system in which its benefits are targeted at heart issues may seem obvious, less obvious is the behavior of *pharmacy management* systems and the *digital radiology* system. A *pharmacy management* system appears in heart failure and heart attack but is absent in pneumonia portfolios. Conversely, the *digital radiology* system appears in all pneumonia readmission portfolios while not appearing in any targeted at reducing heart issues.

Table 13 details the collective IT systems that appear in the candidate portfolios. These systems, at least initially, appear to be most effective in improving quality for their selective areas of specialization.

Table 13. Systems Effective in Addressing Specific Healthcare Metrics

Quality Metric	Effective HIT Systems
Heart Attack	Clinical Decision Support System Cardiology Information System Radiology: Medical Resonance Imaging Emergency Department Information System Pharmacy Management Dictation Laboratory Outreach Services Operating Room Scheduling Dictation with Speech Recognition
Heart Failure	Order Entry Chart Tracking Laboratory Information Systems Microbiology Cardiology: Catheterization Laboratory Pharmacy Management Anatomical Pathology Blood Bank Obstetrical Systems Radiology: Medical Resonance Imaging Consumer Portal Computerized Physician Order Entry
Pneumonia	Dictation Abstracting Radiology: Digital Mammography Operating Room: Pre-Operative Operating Room Scheduling Radiology: Digital Radiography Radiology: Digital Fluoroscopy Operating Room: Post-Operative

CHAPTER 5

CONCLUSIONS

The results outlined in the previous chapter illustrate that synergistic effects are occurring between multiple IT systems within the healthcare arena. The purpose of this research was to introduce an approach to identify portfolios that harness these synergies and to provide a mechanism to confirm their existence. Specifically addressing the research objectives:

Research Objective 1

Identify optimal portfolios of information technology that are positively associated with better than average quality performance at healthcare organizations

As identified earlier, the data mining phase of the approach identified many portfolios associated with *better than national average* quality results. Many of these portfolios contained systems which were individually associated with better than average results. It would be expected that when combining these systems into a portfolio, the resulting accumulative effect on quality would also be positive. Therefore, a portfolio's positive correlation with *better than the national average* is not sufficient to predict that it contains a synergistic effect. However, these portfolios would be suitable candidates for further analysis using logistic regression.

Research Objective 2

Identify if synergistic effects exist between the components of the optimal IT portfolio. Specifically, are individual technologies more positively associated with quality when used in conjunction with other technologies within an IT portfolio than when used in isolation?

Using the second step of the proposed approach - logistic regression, I was able to support the presence of synergistic effects among select HIT systems. These synergistic effects were specific to individual quality metrics, and their effects seem to be mitigated by the presence, or lack of presence, of other IT systems.

Research Contribution and Impact

The results of this research have significant implications for both theory and practice. The exploration of optimal portfolios and synergistic effects adds to the knowledge base of the impact of portfolios on organizational performance by extending it to the case of healthcare and healthcare quality. By applying the portfolio theory to information technology investments within the healthcare context, insights have been gained into a lightly explored subject area using concepts rarely applied in this arena.

Specifically, contributions from this research include:

1. A clearer understanding of HIT's impact on quality, and therefore this may help guide decision-makers when planning and implementing future IT investments. Healthcare administrators seeking to bolster or maximize a particular quality metric for their facility, can compare their current IT system mix to those candidate portfolios, and identify those systems which may provide the greatest return on investment.

2. Understanding the inter-system synergies will guide strategic planners of facilities based on systems previously adopted. Those facilities with the candidate systems already in place, but that are not performing well on the quality metric, will have additional information to inform their performance improvement efforts.

3. The identification of systems that have no, or relatively minor, impact on quality may inform the design of future versions of these systems. Identifying combinations of systems with lower than expected interactions can aid HIT system vendors seeking to enhance their offerings by providing an area of focus for future development.

4. A unique application of Portfolio Theory. To date, the Portfolio Theory has been used extensively but almost exclusively within the finance arena (Bridges, et al., 2002). Extending the application of this well-defined and well-understood theory to the healthcare

domain supports the validity of this research while also expanding the usefulness of the theory.

5. Interdisciplinary Approach: bridging three domains. The approach outlined by this research draws from three independent domains. The Portfolio Theory is borrowed from economics and finance, the data mining techniques are drawn from information technology, and the examination of HIT systems reflects the healthcare domain.

The approach introduced in this research applies best practices while expanding knowledge to deliver unique insights into a timely and important area of study. I foresee that the components of this approach can be extended to apply the IT portfolio concept to domains outside of healthcare, and expand the analysis to focus on or incorporate patient service-quality metrics.

Research Limitations

The data used for this research was provided to the public in the form of two datasets. One dataset was obtained from the federal government, and the other from HIMSS Analytics (a for-profit organization). Neither dataset was designed specifically for this research. Therefore, the data structure and granularity was not ideal. The process followed by developers of the AHRQ dataset to rank the healthcare facilities by their quality metric into the three classifications (*above the national average*, *equal to the national average* or *below the national average*) was not fully detailed. The dataset documentation did not indicate through what mechanisms these facilities were assigned their rating. Furthermore, a large majority of the facilities were assigned an *equal to the national average* rating on each metric. This indicates the parameter's range for this rating must have been rather large. If facilities were ranked into more than three categories, the requirements to receive an average ranking were constrained, or if the facilities performance was reported as a numerical value, greater precision could be attained.

The IT systems reported in the HIMSS dataset did not include extent of system use or user training levels which would helpful to combat endogeneity concerns. However, I believe the large sample size still provides realistic averages. Further, there are many brands of most HIT systems available from multiple vendors, and within a given brand, there may be multiple versions based on the level of functionality as well as chronological updates. Additional granularity could be achieved here if the dataset was more comprehensive.

Other healthcare datasets are available from organizations such as American Academy of Family Physicians, American College of Surgeons, National Center for Health Statistics, U.S. Department of Health & Human Services, Health Resources & Services Administration, Health Workforce Resource Center and others. However, many of these sources sell their datasets to commercial customers for business analytics and other analyses. These sources were cost prohibitive for this research. Publically available data sources reviewed in the early stages of this study, other than the Hospital Compare database, did not report the necessary data of interest.

More current, comprehensive, accurate and robust datasets with finer granularity exist, and will continue to be made available. As future generations of HIT systems advance and mature, their functionality and value to the organization will also transform. In so doing, their synergistic relationships will also surely evolve. Therefore regular application of this approach to updated datasets will be required to ensure that we maintain a clear understanding of HIT’s impact on healthcare quality. Furthermore, conflicting results are certainly possible because the portfolios are based upon multiple outcome metrics. It is foreseeable that a portfolio yielding strong positive synergies for one outcome may also yield strong negative effects for other outcomes. In this case, some mechanism to reconcile these conflicts will need to be developed.

Future Research

In future research, this approach will be applied to newer, larger and more comprehensive datasets. As discussed previously, the greatest limitations to this research stemmed from the restrictions of the data. The data used in this research was publically available. However, more robust datasets are available. Healthcare datasets from organizations such as the National Institute of Health, World Health Organization, and the National Center for Health Statistics are available for download. However, data repositories containing facility implementation and usage of information technology is less available. Fortunately the HIMSS dataset is relatively comprehensive, although recent versions of the database are available for a fee.

During the data mining process, multiple algorithms were reviewed and tested. However, the number and type of algorithms was limited by the capabilities of the WEKA machine learning software which was used solely during the data mining phase. Although the J48 algorithm was selected to develop the decision trees from which the portfolios were extracted, other algorithms exist and current algorithms are occasionally revised. As Wu, et al. (2008) identify, additonal predominant algorithms in data mining are support vector machines, Apriori, PageRank, AdaBoost, *k*NN, Naïve Bayes, and CART.

The Apriori algorithm is one of the most popular data mining approaches used to find frequent groupings from a dataset and develop association rules. Identifying these frequent groupings is important because of vast possible permutations. Once these sets are identified, it is straightforward to generate association rules with the user's predetermined confidence levels. The PageRank algorithm was created by Sergey Brin and Larry Page, the founders of Google. This algorithm calculates a static ranking of Web pages that is not dependent on the number or frequency of search queries. The algorithm bases its ranking of a particular page on two characteristics. The first is the total number of other Web pages that link directly to the target page, and second, the ranking or "importance" of those pages. A variation of this algorithm is used by essentially all search engines as well as providing the foundation for rank prestige in social networks.

The AdaBoost algorithm is an ensemble method of learning. Ensemble learning deals with methods which use multiple learners to solve a problem. The results from this type of learning are more generalizable than results from a single learner. AdaBoost also has a solid theoretical foundation, offers very accurate prediction and great simplicity, needing only 10 lines of code. The k-nearest neighbor classification (kNN) is an extension of the Rote classifier which is considered the simplest of all classifiers as it memorizes the entire training data and performs classification only if the attributes of the test object match one of the training examples exactly. Unfortunately this method of classification can result in the elimination of many objects non-identical objects. The k-nearest neighbor (kNN) classification is more sophisticated because it is able to calculate the nearest neighbor in the training which allows a greater percentage of classified objects.

Naïve Bayes is an algorithm well suited to problems where parameters of classes containing objects are already known, and the goal is to design a rule which will allow the classification of future objects. This is an example of supervised classification. The Naïve Bayes classifier is easy to understand, and while it may not be the optimal classifier for any particular application, it can be expected to perform well. Finally, the Classification and Regression Trees (CART) decision tree is a binary iterative partitioning process which is capable of processing continuous and nominal attributes. Trees are grown to their maximum size and then pruned back to the root via a cost-complexity pruning approach. The next split to be pruned is the one contributing least to the performance of the tree. Although not all of these algorithms are appropriate for the structure of the approach introduced in this research, one or more of these alternate algorithms may offer more refined portfolios.

Most HIT systems are composed of multiple modules or components with each facility implementing varying combinations of these components (Burke, et al., 2002). While the analysis provided was at an aggregate (system) level, in future research I intend to increase the granularity of analysis to specific components of integrated information system products. Additionally, as identified, some IT systems appear to offer greater benefits toward improving quality for specific quality metrics while having little, no, or a negative impact on others. Further precision should be sought to identify which IT systems offer strong positive impacts on other quality metrics not examined in this research.

In this study, four control variables were used (ownership, size, type, and case mix) from the AHRQ Hospital Compare database. The inclusion of additional control variables may offer more accurate results and assist by combating endogeneity. Additional control variables available include system adoption, user training, geography, and facility age. Additionally, the inclusion of time series data from multiple years should provide a clearer understanding of causal relationships (Marinazzo, et al., 2012) as well as a more thorough understanding of how HIT systems mature and system use changes.

Yet another concept of interest, and potentially of tremendous benefit, is the investigation into the existance of a master portfolio that would improve quality by impacting health outcomes across the enterprise. Rather than seeking to improve specific quality metrics, a master portfolio would necessarily contain ample HIT systems to produce a synergistic effect on all metrics.

Finally, although unexpected, the discovery of negative synergistic effects has presented a new dimension to this research. The causal relationships between IT systems that generate negative synergies need to be explored further, as does the potential for conflicting results stemming from multiple outcome metrics. Potentially, multi-criteria decision making technics may offer a method to reconcile these conflicts.

The lack of attention from researchers may make the negative synergies the low-hanging fruit in the effort to improve healthcare quality. Although negative synergies were not the focus on this research, I believe this approach would work equally well to identify them by seeking portfolios associated with below the national average results and then using logistical regression to seek out those portfolios reporting the greatest negative effects. The prevention of negative synergistic effects may prove to be as valuable, if not more so, than the promotion of positive effects.

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APPENDICES

APPENDIX A: DECISION TREES AND CANDIDIATE PORTFOLIOS

Heart Attack Mortality

EDIS <= 0
| CDSS <= 0: No Different than U.S. National Rate (26.0)
| CDSS > 0
| | Phy_Portal <= 0
| | | Card_CT <= 0
| | | | EMAR <= 0
| | | | | Card_Echo <= 0
| | | | | | SSO <= 0
| | | | | | | Phy_Doc <= 0
| | | | | | | | OR_Sched <= 0: No Different than U.S. National Rate (10.0)
| | | | | | | | OR_Sched > 0
| | | | | | | | | Doc_Man <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | Doc_Man > 0: **Better than U.S. National Rate** (15.0)
| | | | | | | Phy_Doc > 0: **Better than U.S. National Rate** (9.0)
| | | | | | SSO > 0: No Different than U.S. National Rate (3.0)
| | | | | Card_Echo > 0: No Different than U.S. National Rate (6.0)
| | | | EMAR > 0: No Different than U.S. National Rate (31.0)
| | | Card_CT > 0
| | | | Elect_Form <= 0
| | | | | Phy_Doc <= 0: No Different than U.S. National Rate (3.0)
| | | | | Phy_Doc > 0: **Better than U.S. National Rate** (9.0)
| | | | Elect_Form > 0: **Better than U.S. National Rate** (13.0)
| | Phy_Portal > 0: No Different than U.S. National Rate (14.0)
EDIS > 0
| Pharm_Man <= 0
| | EDI <= 0: No Different than U.S. National Rate (8.0)
| | EDI > 0
| | | Lab_Outreach <= 0
| | | | Card_Cath Lab <= 0
| | | | | In-House_Transcr <= 0
| | | | | | Order_Entry <= 0: No Different than U.S. National Rate (2.0)
| | | | | | Order_Entry > 0: **Better than U.S. National Rate** (5.0)
| | | | | In-House_Transcr > 0: No Different than U.S. National Rate (6.0)
| | | | Card_Cath Lab > 0
| | | | | Card_Echo <= 0
| | | | | | Radiology_Orthopedic <= 0: **Better than U.S. National Rate** (10.0)
| | | | | | Radiology_Orthopedic > 0: No Different than U.S. National Rate (4.0)
| | | | | Card_Echo > 0: **Better than U.S. National Rate** (47.0/2.0)
| | | Lab_Outreach > 0: No Different than U.S. National Rate (6.0)
| Pharm_Man > 0
| | Dictation <= 0
| | | Card_IS <= 0: No Different than U.S. National Rate (18.0)
| | | Card_IS > 0
| | | | OR_Peri <= 0: No Different than U.S. National Rate (5.0)
| | | | OR_Peri > 0: **Better than U.S. National Rate** (35.0/2.0)
| | Dictation > 0
| | | CDSS <= 0
| | | | Microbiology <= 0: **Better than U.S. National Rate** (19.0/1.0)
| | | | Microbiology > 0: No Different than U.S. National Rate (19.0)

| | | CDSS > 0
| | | | Radiology_ US <= 0
| | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (17.0)
| | | | | Obstetrical_Systems > 0
| | | | | | Microbiology <= 0: No Different than U.S. National Rate (6.0)
| | | | | | Microbiology > 0
| | | | | | | Card_Intravascular_Ultra <= 0
| | | | | | | | OR_Peri <= 0: Worse than U.S. National Rate (27.0)
| | | | | | | | OR_Peri > 0: No Different than U.S. National Rate (13.0)
| | | | | | | Card_Intravascular_Ultra > 0: Worse than U.S. National Rate (57.0)
| | | | Radiology_ US > 0
| | | | | Radiology_MRI <= 0
| | | | | | Nursing_Doc <= 0: Worse than U.S. National Rate (26.0)
| | | | | | Nursing_Doc > 0: No Different than U.S. National Rate (5.0)
| | | | | Radiology_MRI > 0
| | | | | | Radiology_Angiography <= 0
| | | | | | | Radiology_CR <= 0
| | | | | | | | Doc_Man <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | Doc_Man > 0: Worse than U.S. National Rate (19.0)
| | | | | | | Radiology_CR > 0: No Different than U.S. National Rate (23.0)
| | | | | | Radiology_Angiography > 0
| | | | | | | OR_Pre <= 0
| | | | | | | | Radiology_Orthopedic <= 0
| | | | | | | | | Dictation_SR <= 0: No Different than U.S. National Rate (12.0)
| | | | | | | | | Dictation_SR > 0: **Better than U.S. National Rate** (26.0)
| | | | | | | | Radiology_Orthopedic > 0
| | | | | | | | | Lab_Molecular <= 0
| | | | | | | | | | Elect_Form <= 0
| | | | | | | | | | | Phy_Doc <= 0: No Different than U.S. National Rate (12.0)
| | | | | | | | | | | Phy_Doc > 0: Worse than U.S. National Rate (33.0)
| | | | | | | | | | Elect_Form > 0: Worse than U.S. National Rate (92.0/2.0)
| | | | | | | | | Lab_Molecular > 0
| | | | | | | | | | Card_Cath Lab <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | Card_Cath Lab > 0: **Better than U.S. National Rate** (12.0)
| | | | | | | OR_Pre > 0
| | | | | | | | OR_Sched <= 0
| | | | | | | | | Obstetrical_Systems <= 0: Worse than U.S. National Rate (39.0/1.0)
| | | | | | | | | Obstetrical_Systems > 0: No Different than U.S. National Rate (10.0)
| | | | | | | | OR_Sched > 0
| | | | | | | | | Card_IS <= 0
| | | | | | | | | | Radiology_DM <= 0
| | | | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (15.0)
| | | | | | | | | | | Resp_Care_IS > 0
| | | | | | | | | | | | Intensive_Care <= 0: **Better than U.S. National Rate** (41.0/2.0)
| | | | | | | | | | | | Intensive_Care > 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | Radiology_DM > 0: No Different than U.S. National Rate (39.0)
| | | | | | | | | Card_IS > 0
| | | | | | | | | | Outcomes and Quality Management <= 0
| | | | | | | | | | | CPOE <= 0: No Different than U.S. National Rate (18.0)
| | | | | | | | | | | CPOE > 0
| | | | | | | | | | | | OR_Peri <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | OR_Peri > 0
| | | | | | | | | | | | | Lab_Outreach <= 0
| | | | | | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | | | | | Radiology_DM <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | Radiology_DM > 0: **Better than U.S. National Rate** (42.0)
| | | | | | | | | | | | | | Con_Portal > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | Lab_Outreach > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | Outcomes and Quality Management > 0
| | | | | | | | | | | Nursing_Doc <= 0
| | | | | | | | | | | | Card_Echo <= 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | | | Card_Echo > 0
| | | | | | | | | | | | | Radiology_DM <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | Radiology_DM > 0: **Better than U.S. National Rate** (21.0)
| | | | | | | | | | | Nursing_Doc > 0
| | | | | | | | | | | | Blood_Bank <= 0
| | | | | | | | | | | | | Card_Echo <= 0
| | | | | | | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | Resp_Care_IS > 0: Worse than U.S. National Rate (19.0)
| | | | | | | | | | | | | Card_Echo > 0: No Different than U.S. National Rate (12.0)

| | | | | | | | | | | | Blood_Bank > 0
| | | | | | | | | | | | | Lab_Outreach <= 0
| | | | | | | | | | | | | | Abstracting <= 0: **Better than U.S. National Rate** (11.0/1.0)
| | | | | | | | | | | | | | Abstracting > 0
| | | | | | | | | | | | | | | OR_Post <= 0: Worse than U.S. National Rate (27.0/1.0)
| | | | | | | | | | | | | | | OR_Post > 0
| | | | | | | | | | | | | | | | Lab_IS <= 0: **Better than U.S. National Rate** (10.0)
| | | | | | | | | | | | | | | | Lab_IS > 0
| | | | | | | | | | | | | | | | | Chart_Track <= 0: Worse than U.S. National Rate (24.0/1.0)
| | | | | | | | | | | | | | | | | Chart_Track > 0
| | | | | | | | | | | | | | | | | | Card_Cath Lab <= 0
| | | | | | | | | | | | | | | | | | | Elect_Form <= 0: No Different than U.S. National Rate (25.0)
| | | | | | | | | | | | | | | | | | | Elect_Form > 0
| | | | | | | | | | | | | | | | | | | | SSO <= 0
| | | | | | | | | | | | | | | | | | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | | | | | | | | | | | EMAR <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | | | | | EMAR > 0
| | | | | | | | | | | | | | | | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | | | | | | | | | | | | | | | In-House_Transcr <= 0: **Better than U.S. National Rate** (7.0)
| | | | | | | | | | | | | | | | | | | | | | | | In-House_Transcr > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | | | | | | | | | Phy_Doc > 0: **Better than U.S. National Rate** (29.0/1.0)
| | | | | | | | | | | | | | | | | | | | SSO > 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | | | | | | | | | Card_Cath Lab > 0
| | | | | | | | | | | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | | | | | | | | | | Phy_Portal <= 0
| | | | | | | | | | | | | | | | | | | | | EDI <= 0
| | | | | | | | | | | | | | | | | | | | | | In-House_Transcr <= 0: Worse than U.S. National Rate (23.0/2.0)
| | | | | | | | | | | | | | | | | | | | | | In-House_Transcr > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | | | | | | EDI > 0
| | | | | | | | | | | | | | | | | | | | | | Doc_Man <= 0
| | | | | | | | | | | | | | | | | | | | | | | Phy_Doc <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | | | | | | | | Phy_Doc > 0: **Better than U.S. National Rate** (23.0)
| | | | | | | | | | | | | | | | | | | | | | Doc_Man > 0: No Different than U.S. National Rate (12.0)
| | | | | | | | | | | | | | | | | | | | Phy_Portal > 0
| | | | | | | | | | | | | | | | | | | | | Card_CT <= 0: Worse than U.S. National Rate (37.0)
| | | | | | | | | | | | | | | | | | | | | Card_CT > 0
| | | | | | | | | | | | | | | | | | | | | | Card_Intravascular_Ultra <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | | | | | | | | Card_Intravascular_Ultra > 0
| | | | | | | | | | | | | | | | | | | | | | | Card_Nuclear_Card <= 0: Worse than U.S. National Rate (39.0)
| | | | | | | | | | | | | | | | | | | | | | | Card_Nuclear_Card > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | | | | | Con_Portal > 0: No Different than U.S. National Rate (17.0)
| | | | | | | | | | | | | Lab_Outreach > 0
| | | | | | | | | | | | | | Radiology_Orthopedic <= 0: No Different than U.S. National Rate (13.0)
| | | | | | | | | | | | | | Radiology_Orthopedic > 0
| | | | | | | | | | | | | | | Intensive_Care <= 0: Worse than U.S. National Rate (16.0/1.0)
| | | | | | | | | | | | | | | Intensive_Care > 0
| | | | | | | | | | | | | | | | EDI <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | EDI > 0
| | | | | | | | | | | | | | | | | In-House_Transcr <= 0
| | | | | | | | | | | | | | | | | | Transcr_Remote <= 0: Worse than U.S. National Rate (15.0/1.0)
| | | | | | | | | | | | | | | | | | Transcr_Remote > 0: **Better than U.S. National Rate** (18.0)
| | | | | | | | | | | | | | | | | In-House_Transcr > 0
| | | | | | | | | | | | | | | | | | Phy_Portal <= 0
| | | | | | | | | | | | | | | | | | | Radiology_DM <= 0: **Better than U.S. National Rate** (5.0)
| | | | | | | | | | | | | | | | | | | Radiology_DM > 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | | | | | | | | | Phy_Portal > 0
| | | | | | | | | | | | | | | | | | | OR_Peri <= 0: **Better than U.S. National Rate** (29.0)
| | | | | | | | | | | | | | | | | | | OR_Peri > 0
| | | | | | | | | | | | | | | | | | | | Card_CT <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | | | | | | Card_CT > 0
| | | | | | | | | | | | | | | | | | | | | CPOE <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | | | | CPOE > 0: **Better than U.S. National Rate** (34.0/2.0)

Number of Leaves : 92

Size of the tree : 183

23 Portfolios

1. CDSS, OR_Scheduling, Document_Management
2. CDSS, Physician_Documentation
3. CDSS, Cardiology_CT, Physician_Documentation
4. CDSS, Cardiology_CT, Electronic_Forms
5. EDIS, EDI, Order_Entry
6. EDIS, EDI, Cardiology_Cath Lab
7. EDIS, EDI, Cardiology_Cath Lab, Cardiology_Echocardiology
8. EDIS, Pharmacy_Management, Cardiology_IS, Operating_Room_Peri
9. EDIS, Pharmacy_Management, Dictation
10. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Dictation_Speech_Recognition
11. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Radiology_Orthopedic, Lab_Molecular, Cardiology_Cath Lab
12. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Respitory_Care_IS
13. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, CPOE, Operating_Room_Peri, Radiology_DM
14. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Cardiology_Echocardiology, Radiology_DM
15. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank
16. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank, Abstracting, Operating_Room_Post
17. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank, Abstracting, Operating_Room_Post, Laboratory_IS, Chart_Tracking, Electronic_Forms, Obstetrical_Systems, EMAR
18. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank, Abstracting, Operating_Room_Post, Laboratory_IS, Chart_Tracking, Electronic_Forms, Obstetrical_Systems, EMAR, Physician_Documentation

19. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank, Abstracting, Operating_Room_Post, Laboratory_IS, Chart_Tracking, Cardiology_Cath Lab, EDI, Physician_Documentation
20. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank, Lab_Outreach, Radiology_Orthopedic, Intensive Care, EDI, Transcription_Remote_Hosted/ASP
21. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank, Lab_Outreach, Radiology_Orthopedic, Intensive Care, EDI, In-House_Trancription
22. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank, Lab_Outreach, Radiology_Orthopedic, Intensive Care, EDI, In-House_Trancription, Physician_Portal,
23. EDIS, Pharmacy_Management, Dictation, CDSS, Radiology_US, Radiology_MRI, Radiology_Angiography, Operating_Room_Pre, OR_Scheduling, Cardiology_IS, Outcomes and Quality Management, Nursing Doc, Blood Bank, Lab_Outreach, Radiology_Orthopedic, Intensive Care, EDI, In-House_Trancription, Physician_Portal, Operating_Room_Peri, Cardiology_CT, CPOE

Heart Attack Readmission

OR_Sched <= 0: No Different than U.S. National Rate (98.0)
OR_Sched > 0
| Radiology_DR <= 0: No Different than U.S. National Rate (39.0)
| Radiology_DR > 0
| | Transcr_Remote <= 0
| | | Card_Intravascular_Ultra <= 0
| | | | Con_Portal <= 0
| | | | | Phy_Portal <= 0
| | | | | | Microbiology <= 0: Worse than U.S. National Rate (66.0/2.0)
| | | | | | Microbiology > 0
| | | | | | | Dictation_SR <= 0
| | | | | | | | Anat_Path <= 0: No Different than U.S. National Rate (15.0)
| | | | | | | | Anat_Path > 0
| | | | | | | | | Resp_Care_IS <= 0
| | | | | | | | | | Card_IS <= 0
| | | | | | | | | | | Card_Echo <= 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | | Card_Echo > 0: Worse than U.S. National Rate (17.0)
| | | | | | | | | | Card_IS > 0
| | | | | | | | | | | In-House_Transcr <= 0: Worse than U.S. National Rate (123.0/1.0)
| | | | | | | | | | | In-House_Transcr > 0
| | | | | | | | | | | | Nursing_Doc <= 0
| | | | | | | | | | | | | Radiology_DM <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | Radiology_DM > 0: Worse than U.S. National Rate (57.0)
| | | | | | | | | | | | Nursing_Doc > 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | Resp_Care_IS > 0
| | | | | | | | | | EMAR <= 0: No Different than U.S. National Rate (22.0)
| | | | | | | | | | EMAR > 0
| | | | | | | | | | | Radiology_DM <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | Radiology_DM > 0
| | | | | | | | | | | | EDI <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | EDI > 0
| | | | | | | | | | | | | Card_Cath Lab <= 0
| | | | | | | | | | | | | | Obstetrical_Systems <= 0: Worse than U.S. National Rate (31.0)
| | | | | | | | | | | | | | Obstetrical_Systems > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | Card_Cath Lab > 0: Worse than U.S. National Rate (66.0/1.0)
| | | | | | | Dictation_SR > 0: No Different than U.S. National Rate (29.0)
| | | | | Phy_Portal > 0
| | | | | | EDI <= 0
| | | | | | | OR_Peri <= 0: Worse than U.S. National Rate (23.0)
| | | | | | | OR_Peri > 0: No Different than U.S. National Rate (7.0)
| | | | | | EDI > 0
| | | | | | | Radiology_DM <= 0
| | | | | | | | CPOE <= 0: No Different than U.S. National Rate (13.0)
| | | | | | | | CPOE > 0
| | | | | | | | | In-House_Transcr <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | In-House_Transcr > 0: **Better than U.S. National Rate** (56.0)
| | | | | | | Radiology_DM > 0: No Different than U.S. National Rate (26.0)
| | | | Con_Portal > 0
| | | | | Phy_Portal <= 0
| | | | | | EMAR <= 0: No Different than U.S. National Rate (11.0)
| | | | | | EMAR > 0
| | | | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | Obstetrical_Systems > 0
| | | | | | | | In-House_Transcr <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | In-House_Transcr > 0
| | | | | | | | | OR_Peri <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | OR_Peri > 0: **Better than U.S. National Rate** (49.0/2.0)
| | | | | Phy_Portal > 0: No Different than U.S. National Rate (24.0)
| | | Card_Intravascular_Ultra > 0
| | | | CDSS <= 0
| | | | | Order_Entry <= 0: No Different than U.S. National Rate (3.0)
| | | | | Order_Entry > 0: Worse than U.S. National Rate (36.0)
| | | | CDSS > 0
| | | | | Radiology_Orthopedic <= 0: No Different than U.S. National Rate (29.0)
| | | | | Radiology_Orthopedic > 0

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|  |  |  |  |  |  In-House_Transcr <= 0: No Different than U.S. National Rate (17.0)
|  |  |  |  |  |  In-House_Transcr > 0
|  |  |  |  |  |  |  Lab_Outreach <= 0
|  |  |  |  |  |  |  |  Phy_Doc <= 0: No Different than U.S. National Rate (12.0)
|  |  |  |  |  |  |  |  Phy_Doc > 0
|  |  |  |  |  |  |  |  |  Dictation_SR <= 0
|  |  |  |  |  |  |  |  |  |  OR_Peri <= 0: No Different than U.S. National Rate (2.0)
|  |  |  |  |  |  |  |  |  |  OR_Peri > 0
|  |  |  |  |  |  |  |  |  |  |  Lab_Molecular <= 0: Better than U.S. National Rate (43.0/2.0)
|  |  |  |  |  |  |  |  |  |  |  Lab_Molecular > 0: No Different than U.S. National Rate (2.0)
|  |  |  |  |  |  |  |  |  Dictation_SR > 0: No Different than U.S. National Rate (3.0)
|  |  |  |  |  |  |  Lab_Outreach > 0
|  |  |  |  |  |  |  |  Dictation_SR <= 0: No Different than U.S. National Rate (6.0)
|  |  |  |  |  |  |  |  Dictation_SR > 0
|  |  |  |  |  |  |  |  |  Lab_Molecular <= 0
|  |  |  |  |  |  |  |  |  |  Resp_Care_IS <= 0: Better than U.S. National Rate (30.0)
|  |  |  |  |  |  |  |  |  |  Resp_Care_IS > 0: No Different than U.S. National Rate (4.0)
|  |  |  |  |  |  |  |  |  Lab_Molecular > 0: Better than U.S. National Rate (101.0/3.0)
|  |  Transcr_Remote > 0
|  |  |  Card_IS <= 0: No Different than U.S. National Rate (9.0)
|  |  |  Card_IS > 0
|  |  |  |  Phy_Portal <= 0
|  |  |  |  |  Con_Portal <= 0: No Different than U.S. National Rate (13.0)
|  |  |  |  |  Con_Portal > 0: Better than U.S. National Rate (15.0/1.0)
|  |  |  |  Phy_Portal > 0
|  |  |  |  |  Card_Intravascular_Ultra <= 0: Better than U.S. National Rate (89.0/2.0)
|  |  |  |  |  Card_Intravascular_Ultra > 0
|  |  |  |  |  |  Chart_Track <= 0: Better than U.S. National Rate (27.0)
|  |  |  |  |  |  Chart_Track > 0: No Different than U.S. National Rate (7.0)

Number of Leaves  :   48
```

8 Portfolios

1. OR_Scheduling, Radiology_DR, Physician_Portal, EDI, CPOE, In-House_Transcription
2. OR_Scheduling, Radiology_DR, Consumer_Portal, EMAR, Obstetrical Systems, In-House_Transcription, Operating_Room_Peri
3. OR_Scheduling, Radiology_DR, Cardiology_Intravascular_Ultra, CDSS, Radiology_Orthopedic, In-House_Transcription, Physician_Documentation, Operating_Room_Peri
4. OR_Scheduling, Radiology_DR, Cardiology_Intravascular_Ultra, CDSS, Radiology_Orthopedic, In-House_Transcription, Lab_Outreach, Dictation_Speech_Recognition
5. OR_Scheduling, Radiology_DR, Cardiology_Intravascular_Ultra, CDSS, Radiology_Orthopedic, In-House_Transcription, Lab_Outreach, Dictation_Speech_Recognition, Lab_Molecular
6. OR_Scheduling, Radiology_DR, Transcription_Remote_Hosted/ASP, Cardiology_IS, Consumer_Portal
7. OR_Scheduling, Radiology_DR, Transcription_Remote_Hosted/ASP, Cardiology_IS, Physician_Portal
8. OR_Scheduling, Radiology_DR, Transcription_Remote_Hosted/ASP, Cardiology_IS, Physician_Portal, Cardiology_Intravascular_Ultra

Heart Failure Mortality

Card_Cath Lab <= 0
| Lab_Outreach <= 0
| | Lab_Molecular <= 0
| | | Card_Echo <= 0
| | | | Order_Entry <= 0
| | | | | Radiology_Orthopedic <= 0
| | | | | | Dictation <= 0
| | | | | | | Card_IS <= 0
| | | | | | | | Chart_Track <= 0: No Different than U.S. National Rate (14.0)
| | | | | | | | Chart_Track > 0: **Better than U.S. National Rate** (4.0)
| | | | | | | Card_IS > 0: Worse than U.S. National Rate (5.0)
| | | | | | Dictation > 0
| | | | | | | Nursing_Doc <= 0
| | | | | | | | OR_Peri <= 0
| | | | | | | | | OR_Sched <= 0
| | | | | | | | | | Abstracting <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | Abstracting > 0
| | | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | | CDSS <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | CDSS > 0: **Better than U.S. National Rate** (7.0/1.0)
| | | | | | | | | | | Con_Portal > 0: **Better than U.S. National Rate** (24.0/1.0)
| | | | | | | | | OR_Sched > 0: **Better than U.S. National Rate** (18.0)
| | | | | | | | OR_Peri > 0: No Different than U.S. National Rate (3.0)
| | | | | | | Nursing_Doc > 0
| | | | | | | | Card_Nuclear_Card <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | Card_Nuclear_Card > 0: **Better than U.S. National Rate** (2.0)
| | | | | Radiology_Orthopedic > 0: No Different than U.S. National Rate (11.0)
| | | | Order_Entry > 0
| | | | | Chart_Track <= 0: No Different than U.S. National Rate (23.0)
| | | | | Chart_Track > 0
| | | | | | Lab_IS <= 0
| | | | | | | EDIS <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | EDIS > 0
| | | | | | | | OR_Peri <= 0: Worse than U.S. National Rate (18.0/1.0)
| | | | | | | | OR_Peri > 0: No Different than U.S. National Rate (2.0)
| | | | | | Lab_IS > 0
| | | | | | | Microbiology <= 0
| | | | | | | | Dictation <= 0: **Better than U.S. National Rate** (3.0)
| | | | | | | | Dictation > 0: No Different than U.S. National Rate (38.0)
| | | | | | | Microbiology > 0
| | | | | | | | Card_IS <= 0
| | | | | | | | | CPOE <= 0
| | | | | | | | | | OR_Sched <= 0
| | | | | | | | | | | Radiology_DR <= 0
| | | | | | | | | | | | Obstetrical_Systems <= 0
| | | | | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | | | | SSO <= 0
| | | | | | | | | | | | | | | Radiology_IS <= 0: **Better than U.S. National Rate** (6.0)
| | | | | | | | | | | | | | | Radiology_IS > 0
| | | | | | | | | | | | | | | | Anat_Path <= 0: No Different than U.S. National Rate (10.0)
| | | | | | | | | | | | | | | | Anat_Path > 0
| | | | | | | | | | | | | | | | | Outcomes and Quality Management <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | | Outcomes and Quality Management > 0: **Better than U.S. National Rate** (10.0/1.0)
| | | | | | | | | | | | | | SSO > 0
| | | | | | | | | | | | | | | In-House_Transcr <= 0
| | | | | | | | | | | | | | | | Dictation <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | | Dictation > 0: Worse than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | In-House_Transcr > 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | | Con_Portal > 0: **Better than U.S. National Rate** (8.0)
| | | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | | In-House_Transcr <= 0: Worse than U.S. National Rate (7.0)
| | | | | | | | | | | | | In-House_Transcr > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | Radiology_DR > 0: No Different than U.S. National Rate (34.0)
| | | | | | | | | | OR_Sched > 0
| | | | | | | | | | | Phy_Doc <= 0

| | | | | | | | | | | | Obstetrical_Systems <= 0
| | | | | | | | | | | | | Dictation <= 0
| | | | | | | | | | | | | | Phy_Portal <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | Phy_Portal > 0: **Better than U.S. National Rate** (6.0)
| | | | | | | | | | | | | Dictation > 0
| | | | | | | | | | | | | | Outcomes and Quality Management <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | | | Outcomes and Quality Management > 0
| | | | | | | | | | | | | | | EMAR <= 0
| | | | | | | | | | | | | | | | Radiology_DM <= 0
| | | | | | | | | | | | | | | | | Doc_Man <= 0: Worse than U.S. National Rate (18.0)
| | | | | | | | | | | | | | | | | Doc_Man > 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | Radiology_DM > 0: Worse than U.S. National Rate (38.0)
| | | | | | | | | | | | | | | EMAR > 0
| | | | | | | | | | | | | | | | OR_Post <= 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | | OR_Post > 0
| | | | | | | | | | | | | | | | | EDI <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | | EDI > 0
| | | | | | | | | | | | | | | | | | Doc_Man <= 0: **Better than U.S. National Rate** (3.0)
| | | | | | | | | | | | | | | | | | Doc_Man > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | | SSO <= 0
| | | | | | | | | | | | | | OR_Post <= 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | | | | | OR_Post > 0
| | | | | | | | | | | | | | | Blood_Bank <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | Blood_Bank > 0
| | | | | | | | | | | | | | | | Radiology_DR <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | | Radiology_DR > 0
| | | | | | | | | | | | | | | | | Phy_Portal <= 0
| | | | | | | | | | | | | | | | | | EDI <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | EDI > 0: Worse than U.S. National Rate (42.0/2.0)
| | | | | | | | | | | | | | | | | Phy_Portal > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | SSO > 0: No Different than U.S. National Rate (24.0)
| | | | | | | | | | | Phy_Doc > 0
| | | | | | | | | | | | EMAR <= 0
| | | | | | | | | | | | | OR_Post <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | OR_Post > 0
| | | | | | | | | | | | | | Resp_Care_IS <= 0: **Better than U.S. National Rate** (6.0)
| | | | | | | | | | | | | | Resp_Care_IS > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | EMAR > 0: No Different than U.S. National Rate (26.0)
| | | | | | | | | CPOE > 0: No Different than U.S. National Rate (32.0)
| | | | | | | | Card_IS > 0
| | | | | | | | | CDSS <= 0
| | | | | | | | | | EDIS <= 0: Worse than U.S. National Rate (9.0)
| | | | | | | | | | EDIS > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | CDSS > 0
| | | | | | | | | | Radiology_CT <= 0
| | | | | | | | | | | SSO <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | SSO > 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | Radiology_CT > 0
| | | | | | | | | | | Anat_Path <= 0: No Different than U.S. National Rate (10.0)
| | | | | | | | | | | Anat_Path > 0
| | | | | | | | | | | | Radiology_DF <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | Radiology_DF > 0
| | | | | | | | | | | | | Chart_Def <= 0: **Better than U.S. National Rate** (5.0)
| | | | | | | | | | | | | Chart_Def > 0
| | | | | | | | | | | | | | CPOE <= 0
| | | | | | | | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | | | | | | | EDIS <= 0
| | | | | | | | | | | | | | | | | In-House_Transcr <= 0: **Better than U.S. National Rate** (9.0)
| | | | | | | | | | | | | | | | | In-House_Transcr > 0
| | | | | | | | | | | | | | | | | | Phy_Portal <= 0: **Better than U.S. National Rate** (7.0)
| | | | | | | | | | | | | | | | | | Phy_Portal > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | EDIS > 0
| | | | | | | | | | | | | | | | | EMAR <= 0
| | | | | | | | | | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | | | | | | | | | SSO <= 0
| | | | | | | | | | | | | | | | | | | | OR_Peri <= 0: **Better than U.S. National Rate** (10.0/1.0)
| | | | | | | | | | | | | | | | | | | | OR_Peri > 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | | | | SSO > 0: **Better than U.S. National Rate** (17.0)
| | | | | | | | | | | | | | | | | | Con_Portal > 0: No Different than U.S. National Rate (2.0)

| | | | | | | | | | | | | | | | | EMAR > 0: No Different than U.S. National Rate (10.0/1.0)
| | | | | | | | | | | | | | | Phy_Doc > 0
| | | | | | | | | | | | | | | | In-House_Transcr <= 0: **Better than U.S. National Rate** (16.0/1.0)
| | | | | | | | | | | | | | | | In-House_Transcr > 0: No Different than U.S. National Rate (12.0)
| | | | | | | | | | | | | | CPOE > 0
| | | | | | | | | | | | | | | Outcomes and Quality Management <= 0
| | | | | | | | | | | | | | | | OR_Post <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | OR_Post > 0: **Better than U.S. National Rate** (3.0)
| | | | | | | | | | | | | | | Outcomes and Quality Management > 0
| | | | | | | | | | | | | | | | EDI <= 0
| | | | | | | | | | | | | | | | | Phy_Portal <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | Phy_Portal > 0: Worse than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | EDI > 0: No Different than U.S. National Rate (14.0)
| | | Card_Echo > 0
| | | | Dictation_SR <= 0
| | | | | Card_Intravascular_Ultra <= 0
| | | | | | Lab_IS <= 0
| | | | | | | Card_IS <= 0: **Better than U.S. National Rate** (5.0)
| | | | | | | Card_IS > 0: No Different than U.S. National Rate (2.0)
| | | | | | Lab_IS > 0
| | | | | | | Resp_Care_IS <= 0
| | | | | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | Obstetrical_Systems > 0: Worse than U.S. National Rate (44.0/1.0)
| | | | | | | Resp_Care_IS > 0
| | | | | | | | Card_IS <= 0: **Better than U.S. National Rate** (6.0)
| | | | | | | | Card_IS > 0
| | | | | | | | | OR_Peri <= 0: Worse than U.S. National Rate (9.0)
| | | | | | | | | OR_Peri > 0: No Different than U.S. National Rate (5.0)
| | | | | Card_Intravascular_Ultra > 0: No Different than U.S. National Rate (3.0)
| | | | Dictation_SR > 0
| | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (6.0)
| | | | | Resp_Care_IS > 0
| | | | | | Card_IS <= 0: **Better than U.S. National Rate** (11.0)
| | | | | | Card_IS > 0
| | | | | | | In-House_Transcr <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | In-House_Transcr > 0
| | | | | | | | Phy_Portal <= 0
| | | | | | | | | CPOE <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | CPOE > 0: **Better than U.S. National Rate** (3.0)
| | | | | | | | Phy_Portal > 0: **Better than U.S. National Rate** (12.0)
| | Lab_Molecular > 0
| | | Radiology_DM <= 0: No Different than U.S. National Rate (10.0)
| | | Radiology_DM > 0
| | | | Doc_Man <= 0: Worse than U.S. National Rate (18.0)
| | | | Doc_Man > 0: No Different than U.S. National Rate (3.0)
| Lab_Outreach > 0
| | Transcr_Remote <= 0
| | | EDIS <= 0
| | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (3.0)
| | | | Obstetrical_Systems > 0: Worse than U.S. National Rate (42.0)
| | | EDIS > 0
| | | | Nursing_Doc <= 0
| | | | | Dictation_SR <= 0: No Different than U.S. National Rate (5.0)
| | | | | Dictation_SR > 0: **Better than U.S. National Rate** (10.0)
| | | | Nursing_Doc > 0
| | | | | Radiology_Orthopedic <= 0
| | | | | | Card_IS <= 0: No Different than U.S. National Rate (18.0)
| | | | | | Card_IS > 0
| | | | | | | EMAR <= 0: **Better than U.S. National Rate** (8.0)
| | | | | | | EMAR > 0
| | | | | | | | Dictation_SR <= 0: Worse than U.S. National Rate (7.0)
| | | | | | | | Dictation_SR > 0: No Different than U.S. National Rate (2.0)
| | | | | Radiology_Orthopedic > 0
| | | | | | Phy_Portal <= 0
| | | | | | | In-House_Transcr <= 0: Worse than U.S. National Rate (12.0)
| | | | | | | In-House_Transcr > 0
| | | | | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (7.0)
| | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | Elect_Form <= 0: Worse than U.S. National Rate (21.0)
| | | | | | | | | Elect_Form > 0

| | | | | | | | | | CPOE <= 0: Worse than U.S. National Rate (9.0)
| | | | | | | | | | CPOE > 0: No Different than U.S. National Rate (3.0)
| | | | | | Phy_Portal > 0: No Different than U.S. National Rate (4.0)
| | Transcr_Remote > 0: No Different than U.S. National Rate (9.0)
Card_Cath Lab > 0
| Pharm_Man <= 0
| | Elect_Form <= 0
| | | Dictation_SR <= 0: No Different than U.S. National Rate (6.0)
| | | Dictation_SR > 0: **Better than U.S. National Rate** (6.0/1.0)
| | Elect_Form > 0: **Better than U.S. National Rate** (24.0/1.0)
| Pharm_Man > 0
| | In-House_Transcr <= 0
| | | Chart_Track <= 0
| | | | Card_Echo <= 0: Worse than U.S. National Rate (8.0)
| | | | Card_Echo > 0
| | | | | Doc_Man <= 0: **Better than U.S. National Rate** (2.0)
| | | | | Doc_Man > 0: No Different than U.S. National Rate (2.0)
| | | Chart_Track > 0
| | | | Anat_Path <= 0
| | | | | Obstetrical_Systems <= 0: **Better than U.S. National Rate** (4.0)
| | | | | Obstetrical_Systems > 0: No Different than U.S. National Rate (7.0/1.0)
| | | | Anat_Path > 0
| | | | | Intensive_Care <= 0
| | | | | | CDSS <= 0: **Better than U.S. National Rate** (5.0)
| | | | | | CDSS > 0
| | | | | | | OR_Peri <= 0: Worse than U.S. National Rate (7.0/1.0)
| | | | | | | OR_Peri > 0: No Different than U.S. National Rate (6.0)
| | | | | Intensive_Care > 0
| | | | | | EDI <= 0
| | | | | | | SSO <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | SSO > 0
| | | | | | | | Radiology_Orthopedic <= 0
| | | | | | | | | CPOE <= 0: Worse than U.S. National Rate (10.0)
| | | | | | | | | CPOE > 0: **Better than U.S. National Rate** (5.0)
| | | | | | | | Radiology_Orthopedic > 0: **Better than U.S. National Rate** (17.0/1.0)
| | | | | | EDI > 0
| | | | | | | Card_Echo <= 0
| | | | | | | | Transcr_Remote <= 0
| | | | | | | | | Elect_Form <= 0: Worse than U.S. National Rate (2.0)
| | | | | | | | | Elect_Form > 0: **Better than U.S. National Rate** (11.0)
| | | | | | | | Transcr_Remote > 0: No Different than U.S. National Rate (2.0)
| | | | | | | Card_Echo > 0
| | | | | | | | EMAR <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | EMAR > 0
| | | | | | | | | Card_Nuclear_Card <= 0
| | | | | | | | | | Dictation_SR <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | Dictation_SR > 0: **Better than U.S. National Rate** (20.0)
| | | | | | | | | Card_Nuclear_Card > 0
| | | | | | | | | | Radiology_Orthopedic <= 0: **Better than U.S. National Rate** (29.0)
| | | | | | | | | | Radiology_Orthopedic > 0
| | | | | | | | | | | Radiology_DM <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | Radiology_DM > 0
| | | | | | | | | | | | Transcr_Remote <= 0: **Better than U.S. National Rate** (32.0/1.0)
| | | | | | | | | | | | Transcr_Remote > 0
| | | | | | | | | | | | | Con_Portal <= 0: **Better than U.S. National Rate** (7.0)
| | | | | | | | | | | | | Con_Portal > 0: No Different than U.S. National Rate (4.0)
| | In-House_Transcr > 0
| | | Transcr_Remote <= 0
| | | | Radiology_IS <= 0: Worse than U.S. National Rate (17.0)
| | | | Radiology_IS > 0
| | | | | CDSS <= 0
| | | | | | Card_CT <= 0: Worse than U.S. National Rate (13.0)
| | | | | | Card_CT > 0: No Different than U.S. National Rate (4.0)
| | | | | CDSS > 0
| | | | | | Anat_Path <= 0
| | | | | | | CPOE <= 0: **Better than U.S. National Rate** (21.0/1.0)
| | | | | | | CPOE > 0: No Different than U.S. National Rate (5.0)
| | | | | | Anat_Path > 0
| | | | | | | OR_Pre <= 0
| | | | | | | | Card_Nuclear_Card <= 0

| | | | | | | | | SSO <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | SSO > 0: Worse than U.S. National Rate (40.0)
| | | | | | | | Card_Nuclear_Card > 0: No Different than U.S. National Rate (9.0)
| | | | | | | OR_Pre > 0
| | | | | | | | Radiology_DF <= 0
| | | | | | | | | Card_Intravascular_Ultra <= 0: No Different than U.S. National Rate (7.0)
| | | | | | | | | Card_Intravascular_Ultra > 0
| | | | | | | | | | Phy_Doc <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | Phy_Doc > 0: **Better than U.S. National Rate** (7.0)
| | | | | | | | Radiology_DF > 0
| | | | | | | | | Card_IS <= 0
| | | | | | | | | | Outcomes and Quality Management <= 0: **Better than U.S. National Rate** (11.0)
| | | | | | | | | | Outcomes and Quality Management > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | Card_IS > 0
| | | | | | | | | | Lab_Molecular <= 0
| | | | | | | | | | | EDIS <= 0
| | | | | | | | | | | | Lab_Outreach <= 0: **Better than U.S. National Rate** (14.0/1.0)
| | | | | | | | | | | | Lab_Outreach > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | EDIS > 0
| | | | | | | | | | | | Doc_Man <= 0
| | | | | | | | | | | | | Obstetrical_Systems <= 0
| | | | | | | | | | | | | | Intensive_Care <= 0: Worse than U.S. National Rate (21.0)
| | | | | | | | | | | | | | Intensive_Care > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | | | CPOE <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | | | CPOE > 0
| | | | | | | | | | | | | | | Phy_Portal <= 0: **Better than U.S. National Rate** (24.0)
| | | | | | | | | | | | | | | Phy_Portal > 0
| | | | | | | | | | | | | | | | Lab_Outreach <= 0: Worse than U.S. National Rate (14.0/1.0)
| | | | | | | | | | | | | | | | Lab_Outreach > 0: **Better than U.S. National Rate** (5.0)
| | | | | | | | | | | | Doc_Man > 0
| | | | | | | | | | | | | Nursing_Doc <= 0
| | | | | | | | | | | | | | Card_CT <= 0: **Better than U.S. National Rate** (6.0)
| | | | | | | | | | | | | | Card_CT > 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | | Nursing_Doc > 0
| | | | | | | | | | | | | | Chart_Track <= 0
| | | | | | | | | | | | | | | Resp_Care_IS <= 0: **Better than U.S. National Rate** (5.0)
| | | | | | | | | | | | | | | Resp_Care_IS > 0: Worse than U.S. National Rate (5.0)
| | | | | | | | | | | | | | Chart_Track > 0
| | | | | | | | | | | | | | | Blood_Bank <= 0
| | | | | | | | | | | | | | | | Card_CT <= 0: **Better than U.S. National Rate** (8.0)
| | | | | | | | | | | | | | | | Card_CT > 0: Worse than U.S. National Rate (17.0/1.0)
| | | | | | | | | | | | | | | Blood_Bank > 0
| | | | | | | | | | | | | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (7.0)
| | | | | | | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | | | | | | Card_Echo <= 0: Worse than U.S. National Rate (41.0/2.0)
| | | | | | | | | | | | | | | | | Card_Echo > 0
| | | | | | | | | | | | | | | | | | EDI <= 0
| | | | | | | | | | | | | | | | | | | Phy_Portal <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | | | | Phy_Portal > 0: **Better than U.S. National Rate** (2.0)
| | | | | | | | | | | | | | | | | | EDI > 0
| | | | | | | | | | | | | | | | | | | OR_Sched <= 0: Worse than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | | | | OR_Sched > 0
| | | | | | | | | | | | | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | | | | | | | | | | | | Lab_Outreach <= 0
| | | | | | | | | | | | | | | | | | | | | | Card_Nuclear_Card <= 0: Worse than U.S. National Rate (16.0/1.0)
| | | | | | | | | | | | | | | | | | | | | | Card_Nuclear_Card > 0: No Different than U.S. National Rate (12.0)
| | | | | | | | | | | | | | | | | | | | | Lab_Outreach > 0
| | | | | | | | | | | | | | | | | | | | | | SSO <= 0: Worse than U.S. National Rate (25.0/1.0)
| | | | | | | | | | | | | | | | | | | | | | SSO > 0
| | | | | | | | | | | | | | | | | | | | | | | Phy_Portal <= 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | | | | | | | | | Phy_Portal > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | | | Phy_Doc > 0: No Different than U.S. National Rate (9.0)
| | | | | | | | | | Lab_Molecular > 0
| | | | | | | | | | | Card_Intravascular_Ultra <= 0
| | | | | | | | | | | | Lab_Outreach <= 0: Worse than U.S. National Rate (14.0)
| | | | | | | | | | | | Lab_Outreach > 0
| | | | | | | | | | | | | Card_Nuclear_Card <= 0: **Better than U.S. National Rate** (26.0)
| | | | | | | | | | | | | Card_Nuclear_Card > 0: Worse than U.S. National Rate (10.0/1.0)
| | | | | | | | | | | Card_Intravascular_Ultra > 0

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|  |  |  |  |  |  |  |  |  |  |  |  |  Intensive_Care <= 0: No Different than U.S. National Rate (5.0)
|  |  |  |  |  |  |  |  |  |  |  |  |  Intensive_Care > 0
|  |  |  |  |  |  |  |  |  |  |  |  |  |  Card_CT <= 0: No Different than U.S. National Rate (3.0)
|  |  |  |  |  |  |  |  |  |  |  |  |  |  Card_CT > 0
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  EDIS <= 0: No Different than U.S. National Rate (2.0)
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  EDIS > 0: Better than U.S. National Rate (41.0/2.0)
|  |  |  Transcr_Remote > 0
|  |  |  |  Card_CT <= 0: No Different than U.S. National Rate (9.0)
|  |  |  |  Card_CT > 0
|  |  |  |  |  Card_IS <= 0: No Different than U.S. National Rate (2.0)
|  |  |  |  |  Card_IS > 0: Better than U.S. National Rate (28.0/1.0)

Number of Leaves:     179
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49 Portfolios

1. Dictation, Abstracting, CDSS
2. Dictation, Abstracting, Consumer_Portal
3. Dictation, OR_Scheduling
4. Dictation, Nursing_Documentation, Cardiology_Nuclear
5. Order Entry, Chart_Tracking, Laboratory_IS
6. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology
7. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Radiology_IS, Anatomical_Pathology, Outcomes and Quality Management
8. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Consumer_Portal
9. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, OR_Scheduling, Physician_Portal
10. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, OR_Scheduling, Dictation, Outcomes and Quality Management, EMAR, Operating_Room_Post, EDI
11. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, OR_Scheduling, Physician_Documentation, Operating_Room_Post
12. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Cardiology_IS, CDSS, Radiology_CT, Anatomical_Pathology, Radiology_DF
13. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Cardiology_IS, CDSS, Radiology_CT, Anatomical_Pathology, Radiology_DF, Chart_Deficiency,
14. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Cardiology_IS, CDSS, Radiology_CT, Anatomical_Pathology, Radiology_DF, Chart_Deficiency, In-House_Transcription
15. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Cardiology_IS, CDSS, Radiology_CT, Anatomical_Pathology, Radiology_DF, Chart_Deficiency, EDIS
16. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Cardiology_IS, CDSS, Radiology_CT, Anatomical_Pathology, Radiology_DF, Chart_Deficiency, EDIS, SINGLE_SIGN-ON
17. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Cardiology_IS, CDSS, Radiology_CT, Anatomical_Pathology, Radiology_DF, Chart_Deficiency, Physician_Documentation

18. Order Entry, Chart_Tracking, Laboratory_IS, Microbiology, Cardiology_IS, CDSS, Radiology_CT, Anatomical_Pathology, Radiology_DF, Chart_Deficiency, CPOE, Operating_Room_Post
19. Cardiology_Echocardiology, Laboratory_IS, Respitory_Care_IS
20. Cardiology_Echocardiology, Dictation, Respitory_Care_IS
21. Cardiology_Echocardiology, Dictation, Respitory_Care_IS, Cardiology_IS, In-House_Trancription, CPOE
22. Cardiology_Echocardiology, Dictation, Respitory_Care_IS, Cardiology_IS, In-House_Trancription, Physician_Portal
23. Lab_Outreach, EDIS, Dictation_Speech_Recognition
24. Lab_Outreach, EDIS, Nursing_Documentation, Cardiology_IS
25. Cardiology_Cath Lab, Dictation_Speech_Recognition
26. Cardiology_Cath Lab, Electronic_Forms
27. Cardiology_Cath Lab, Pharmacy_Management, Cardiology_Echocardiology
28. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking
29. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking, Anatomical_Pathology
30. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking, Anatomical_Pathology, Intensive_Care, Single_Sign-on, CPOE
31. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking, Anatomical_Pathology, Intensive_Care, SINGLE_SIGN-ON, Radiology_Orthopedic
32. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking, Anatomical_Pathology, Intensive_Care, EDI, Electronic_Forms
33. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking, Anatomical_Pathology, Intensive_Care, EDI, Cardiology_Echocardiology, EMAR, Dictation_Speech_Recognition
34. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking, Anatomical_Pathology, Intensive_Care, EDI, Cardiology_Echocardiology, EMAR, Cardiology_Nuclear
35. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking, Anatomical_Pathology, Intensive_Care, EDI, Cardiology_Echocardiology, EMAR, Cardiology_Nuclear, Radiology_Orthopedic, Radiology_DM
36. Cardiology_Cath Lab, Pharmacy_Management, Chart_Tracking, Anatomical_Pathology, Intensive_Care, EDI, Cardiology_Echocardiology, EMAR, Cardiology_Nuclear, Radiology_Orthopedic, Radiology_DM, Transcription_Remote_Hosted/ASP
37. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS
38. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Cardiology_Intravascular_Ultra, Physician_Documentation
39. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF

40. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS
41. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS, EDIS, Obstetrical_Systems, CPOE,
42. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS, EDIS, Obstetrical_Systems, CPOE, Physician_Portal, Lab_Outreach
43. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS, EDIS, Document_Management
44. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS, EDIS, Document_Management, Nursing_Documentation
45. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS, EDIS, Document_Management, Nursing_Documentation, Chart_Tracking
46. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS, EDIS, Document_Management, Nursing_Documentation, Chart_Tracking, Blood_Bank, Obstetrical_Systems, Cardiology_Echocardiology, Physician_Portal
47. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS, Lab_Molecular, Lab_Outreach
48. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Radiology_IS, CDSS, Anatomical_Pathology, Operating_Room_Pre, Radiology_DF, Cardiology_IS, Lab_Molecular, Cardiology_Intravascular_Ultra, Intensive_Care, Cardiology_CT, EDIS
49. Cardiology_Cath Lab, Pharmacy_Management, In-House_Transcription, Transcription_Remote_Hosted/ASP, Cardiology_CT, Cardiology_IS

Heart Failure Readmission

Blood_Bank <= 0
| Card_Nuclear_Card <= 0
| | Con_Portal <= 0
| | | SSO <= 0
| | | | Card_CT <= 0
| | | | | OR_Pre <= 0
| | | | | | Card_Echo <= 0
| | | | | | | In-House_Transcr <= 0
| | | | | | | | Radiology_DM <= 0
| | | | | | | | | CDSS <= 0: No Different than U.S. National Rate (17.0)
| | | | | | | | | CDSS > 0
| | | | | | | | | | EDIS <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | EDIS > 0: Worse than U.S. National Rate (7.0/2.0)
| | | | | | | | Radiology_DM > 0: Worse than U.S. National Rate (7.0/1.0)
| | | | | | | In-House_Transcr > 0
| | | | | | | | Intensive_Care <= 0
| | | | | | | | | Radiology_IS <= 0: Worse than U.S. National Rate (27.0/3.0)
| | | | | | | | | Radiology_IS > 0
| | | | | | | | | | Dictation <= 0
| | | | | | | | | | | CDSS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | CDSS > 0
| | | | | | | | | | | | EDIS <= 0: Worse than U.S. National Rate (14.0)
| | | | | | | | | | | | EDIS > 0
| | | | | | | | | | | | | Radiology_Angiography <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | Radiology_Angiography > 0: Worse than U.S. National Rate (3.0)
| | | | | | | | | | Dictation > 0
| | | | | | | | | | | Card_IS <= 0: No Different than U.S. National Rate (23.0)
| | | | | | | | | | | Card_IS > 0: Worse than U.S. National Rate (5.0/1.0)
| | | | | | | | Intensive_Care > 0
| | | | | | | | | Doc_Man <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | Doc_Man > 0: Worse than U.S. National Rate (24.0/1.0)
| | | | | | Card_Echo > 0: Worse than U.S. National Rate (14.0)
| | | | | OR_Pre > 0
| | | | | | Order_Entry <= 0: Worse than U.S. National Rate (10.0)
| | | | | | Order_Entry > 0
| | | | | | | Nursing_Doc <= 0
| | | | | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (7.0)
| | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | CDSS <= 0: Worse than U.S. National Rate (4.0)
| | | | | | | | | CDSS > 0
| | | | | | | | | | Intensive_Care <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | Intensive_Care > 0: Worse than U.S. National Rate (5.0/2.0)
| | | | | | | Nursing_Doc > 0: No Different than U.S. National Rate (33.0)
| | | | Card_CT > 0: Worse than U.S. National Rate (10.0/1.0)
| | | SSO > 0
| | | | OR_Sched <= 0: No Different than U.S. National Rate (14.0)
| | | | OR_Sched > 0
| | | | | Radiology_CR <= 0
| | | | | | In-House_Transcr <= 0
| | | | | | | Radiology_CT <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | Radiology_CT > 0: Worse than U.S. National Rate (4.0/1.0)
| | | | | | In-House_Transcr > 0: Worse than U.S. National Rate (2.0)
| | | | | Radiology_CR > 0: No Different than U.S. National Rate (4.0)
| | Con_Portal > 0
| | | Anat_Path <= 0
| | | | Intensive_Care <= 0
| | | | | Order_Entry <= 0: Worse than U.S. National Rate (28.0/2.0)
| | | | | Order_Entry > 0: No Different than U.S. National Rate (2.0)
| | | | Intensive_Care > 0: No Different than U.S. National Rate (9.0)
| | | Anat_Path > 0: **Better than U.S. National Rate** (7.0)
| Card_Nuclear_Card > 0
| | CDSS <= 0
| | | Card_CT <= 0: **Better than U.S. National Rate** (11.0)
| | | Card_CT > 0
| | | | OR_Peri <= 0: Worse than U.S. National Rate (10.0)
| | | | OR_Peri > 0: No Different than U.S. National Rate (2.0)
| | CDSS > 0: No Different than U.S. National Rate (16.0)

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Blood_Bank > 0
|   Microbiology <= 0
|   |   Anat_Path <= 0: No Different than U.S. National Rate (25.0)
|   |   Anat_Path > 0
|   |   |   Doc_Man <= 0: No Different than U.S. National Rate (3.0)
|   |   |   Doc_Man > 0: Worse than U.S. National Rate (9.0)
|   Microbiology > 0
|   |   Con_Portal <= 0
|   |   |   Obstetrical_Systems <= 0
|   |   |   |   Card_Cath Lab <= 0
|   |   |   |   |   Card_CT <= 0
|   |   |   |   |   |   Phy_Doc <= 0
|   |   |   |   |   |   |   Resp_Care_IS <= 0
|   |   |   |   |   |   |   |   Dictation <= 0: No Different than U.S. National Rate (5.0)
|   |   |   |   |   |   |   |   Dictation > 0
|   |   |   |   |   |   |   |   |   Dictation_SR <= 0
|   |   |   |   |   |   |   |   |   |   Radiology_Nuclear <= 0
|   |   |   |   |   |   |   |   |   |   |   EDI <= 0: Worse than U.S. National Rate (16.0)
|   |   |   |   |   |   |   |   |   |   |   EDI > 0
|   |   |   |   |   |   |   |   |   |   |   |   In-House_Transcr <= 0: Worse than U.S. National Rate (8.0)
|   |   |   |   |   |   |   |   |   |   |   |   In-House_Transcr > 0
|   |   |   |   |   |   |   |   |   |   |   |   |   Doc_Man <= 0: No Different than U.S. National Rate (4.0)
|   |   |   |   |   |   |   |   |   |   |   |   |   Doc_Man > 0: Worse than U.S. National Rate (7.0/1.0)
|   |   |   |   |   |   |   |   |   |   Radiology_Nuclear > 0
|   |   |   |   |   |   |   |   |   |   |   In-House_Transcr <= 0
|   |   |   |   |   |   |   |   |   |   |   |   OR_Sched <= 0: No Different than U.S. National Rate (2.0)
|   |   |   |   |   |   |   |   |   |   |   |   OR_Sched > 0: Worse than U.S. National Rate (10.0/1.0)
|   |   |   |   |   |   |   |   |   |   |   In-House_Transcr > 0: No Different than U.S. National Rate (20.0)
|   |   |   |   |   |   |   |   |   Dictation_SR > 0: No Different than U.S. National Rate (10.0)
|   |   |   |   |   |   |   Resp_Care_IS > 0: No Different than U.S. National Rate (19.0)
|   |   |   |   |   |   Phy_Doc > 0
|   |   |   |   |   |   |   CDSS <= 0: Worse than U.S. National Rate (6.0)
|   |   |   |   |   |   |   CDSS > 0
|   |   |   |   |   |   |   |   OR_Peri <= 0: No Different than U.S. National Rate (6.0)
|   |   |   |   |   |   |   |   OR_Peri > 0
|   |   |   |   |   |   |   |   |   OR_Sched <= 0: Worse than U.S. National Rate (16.0)
|   |   |   |   |   |   |   |   |   OR_Sched > 0
|   |   |   |   |   |   |   |   |   |   Abstracting <= 0: No Different than U.S. National Rate (2.0)
|   |   |   |   |   |   |   |   |   |   Abstracting > 0
|   |   |   |   |   |   |   |   |   |   |   In-House_Transcr <= 0: Worse than U.S. National Rate (29.0/3.0)
|   |   |   |   |   |   |   |   |   |   |   In-House_Transcr > 0
|   |   |   |   |   |   |   |   |   |   |   |   Radiology_DF <= 0: Worse than U.S. National Rate (2.0)
|   |   |   |   |   |   |   |   |   |   |   |   Radiology_DF > 0
|   |   |   |   |   |   |   |   |   |   |   |   |   SSO <= 0: No Different than U.S. National Rate (9.0)
|   |   |   |   |   |   |   |   |   |   |   |   |   SSO > 0
|   |   |   |   |   |   |   |   |   |   |   |   |   |   Card_IS <= 0: No Different than U.S. National Rate (3.0)
|   |   |   |   |   |   |   |   |   |   |   |   |   |   Card_IS > 0: Worse than U.S. National Rate (3.0)
|   |   |   |   |   Card_CT > 0: Worse than U.S. National Rate (11.0/1.0)
|   |   |   |   Card_Cath Lab > 0
|   |   |   |   |   Transcr_Remote <= 0
|   |   |   |   |   |   Card_Intravascular_Ultra <= 0
|   |   |   |   |   |   |   EMAR <= 0: No Different than U.S. National Rate (9.0)
|   |   |   |   |   |   |   EMAR > 0
|   |   |   |   |   |   |   |   EDIS <= 0: No Different than U.S. National Rate (3.0)
|   |   |   |   |   |   |   |   EDIS > 0
|   |   |   |   |   |   |   |   |   Phy_Doc <= 0
|   |   |   |   |   |   |   |   |   |   SSO <= 0: Better than U.S. National Rate (26.0/1.0)
|   |   |   |   |   |   |   |   |   |   SSO > 0: Worse than U.S. National Rate (7.0)
|   |   |   |   |   |   |   |   |   Phy_Doc > 0
|   |   |   |   |   |   |   |   |   |   Card_Echo <= 0
|   |   |   |   |   |   |   |   |   |   |   Doc_Man <= 0: Worse than U.S. National Rate (3.0)
|   |   |   |   |   |   |   |   |   |   |   Doc_Man > 0: No Different than U.S. National Rate (2.0)
|   |   |   |   |   |   |   |   |   |   Card_Echo > 0: Worse than U.S. National Rate (5.0)
|   |   |   |   |   |   Card_Intravascular_Ultra > 0
|   |   |   |   |   |   |   Radiology_Orthopedic <= 0
|   |   |   |   |   |   |   |   Doc_Man <= 0: Worse than U.S. National Rate (15.0)
|   |   |   |   |   |   |   |   Doc_Man > 0
|   |   |   |   |   |   |   |   |   CPOE <= 0: No Different than U.S. National Rate (2.0)
|   |   |   |   |   |   |   |   |   CPOE > 0: Worse than U.S. National Rate (6.0)
|   |   |   |   |   |   |   Radiology_Orthopedic > 0
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| | | | | | | | CPOE <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | CPOE > 0
| | | | | | | | | Dictation_SR <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | Dictation_SR > 0: Worse than U.S. National Rate (2.0)
| | | | | Transcr_Remote > 0: Worse than U.S. National Rate (27.0/1.0)
| | | Obstetrical_Systems > 0
| | | | CPOE <= 0
| | | | | Transcr_Remote <= 0
| | | | | | Radiology_MRI <= 0
| | | | | | | Doc_Man <= 0: **Better than U.S. National Rate** (33.0/1.0)
| | | | | | | Doc_Man > 0: No Different than U.S. National Rate (4.0)
| | | | | | Radiology_MRI > 0
| | | | | | | Radiology_Angiography <= 0
| | | | | | | | Card_Nuclear_Card <= 0: No Different than U.S. National Rate (21.0)
| | | | | | | | Card_Nuclear_Card > 0: Worse than U.S. National Rate (5.0)
| | | | | | | Radiology_Angiography > 0
| | | | | | | | Pharm_Man <= 0
| | | | | | | | | OR_Sched <= 0: Worse than U.S. National Rate (8.0)
| | | | | | | | | OR_Sched > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | Pharm_Man > 0
| | | | | | | | | Chart_Track <= 0
| | | | | | | | | | Card_CT <= 0
| | | | | | | | | | | Dictation_SR <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | Dictation_SR > 0: **Better than U.S. National Rate** (7.0)
| | | | | | | | | | Card_CT > 0: **Better than U.S. National Rate** (32.0)
| | | | | | | | | Chart_Track > 0
| | | | | | | | | | Doc_Man <= 0
| | | | | | | | | | | Phy_Portal <= 0
| | | | | | | | | | | | Intensive_Care <= 0
| | | | | | | | | | | | | Resp_Care_IS <= 0
| | | | | | | | | | | | | | CDSS <= 0: Worse than U.S. National Rate (3.0)
| | | | | | | | | | | | | | CDSS > 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | | | | Resp_Care_IS > 0: Worse than U.S. National Rate (25.0/1.0)
| | | | | | | | | | | | Intensive_Care > 0
| | | | | | | | | | | | | Radiology_Orthopedic <= 0: No Different than U.S. National Rate (14.0)
| | | | | | | | | | | | | Radiology_Orthopedic > 0
| | | | | | | | | | | | | | CDSS <= 0: Worse than U.S. National Rate (3.0)
| | | | | | | | | | | | | | CDSS > 0
| | | | | | | | | | | | | | | Dictation_SR <= 0: No Different than U.S. National Rate (7.0)
| | | | | | | | | | | | | | | Dictation_SR > 0: Worse than U.S. National Rate (5.0/1.0)
| | | | | | | | | | | Phy_Portal > 0
| | | | | | | | | | | | Card_Echo <= 0: No Different than U.S. National Rate (7.0)
| | | | | | | | | | | | Card_Echo > 0: **Better than U.S. National Rate** (9.0/1.0)
| | | | | | | | | | Doc_Man > 0
| | | | | | | | | | | EDI <= 0
| | | | | | | | | | | | SSO <= 0
| | | | | | | | | | | | | Nursing_Doc <= 0: **Better than U.S. National Rate** (16.0)
| | | | | | | | | | | | | Nursing_Doc > 0
| | | | | | | | | | | | | | EMAR <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | EMAR > 0
| | | | | | | | | | | | | | | Card_Intravascular_Ultra <= 0
| | | | | | | | | | | | | | | | Card_CT <= 0: **Better than U.S. National Rate** (29.0/1.0)
| | | | | | | | | | | | | | | | Card_CT > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | Card_Intravascular_Ultra > 0: **Better than U.S. National Rate** (15.0)
| | | | | | | | | | | | SSO > 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | EDI > 0
| | | | | | | | | | | | Card_IS <= 0
| | | | | | | | | | | | | Anat_Path <= 0
| | | | | | | | | | | | | | Dictation_SR <= 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | | | | | Dictation_SR > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | Anat_Path > 0: No Different than U.S. National Rate (18.0)
| | | | | | | | | | | | Card_IS > 0
| | | | | | | | | | | | | EDIS <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | | EDIS > 0
| | | | | | | | | | | | | | Radiology_Orthopedic <= 0
| | | | | | | | | | | | | | | SSO <= 0
| | | | | | | | | | | | | | | | Card_Cath Lab <= 0
| | | | | | | | | | | | | | | | | EMAR <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | EMAR > 0: Worse than U.S. National Rate (14.0)
| | | | | | | | | | | | | | | | Card_Cath Lab > 0: No Different than U.S. National Rate (8.0)

| | | | | | | | | | | | | | | SSO > 0: **Better than U.S. National Rate** (8.0/1.0)
| | | | | | | | | | | | | | Radiology_Orthopedic > 0
| | | | | | | | | | | | | | | Dictation_SR <= 0
| | | | | | | | | | | | | | | | Card_Cath Lab <= 0: **Better than U.S. National Rate** (9.0)
| | | | | | | | | | | | | | | | Card_Cath Lab > 0
| | | | | | | | | | | | | | | | | Intensive_Care <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | | Intensive_Care > 0: Worse than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | Dictation_SR > 0
| | | | | | | | | | | | | | | | In-House_Transcr <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | In-House_Transcr > 0: **Better than U.S. National Rate** (58.0/5.0)
| | | | | Transcr_Remote > 0
| | | | | | Card_Nuclear_Card <= 0
| | | | | | | Card_CT <= 0
| | | | | | | | Resp_Care_IS <= 0
| | | | | | | | | OR_Sched <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | OR_Sched > 0: Worse than U.S. National Rate (7.0/1.0)
| | | | | | | | Resp_Care_IS > 0: No Different than U.S. National Rate (15.0)
| | | | | | | Card_CT > 0: **Better than U.S. National Rate** (7.0/1.0)
| | | | | | Card_Nuclear_Card > 0: Worse than U.S. National Rate (10.0)
| | | | CPOE > 0
| | | | | Radiology_DF <= 0
| | | | | | Dictation_SR <= 0: No Different than U.S. National Rate (8.0)
| | | | | | Dictation_SR > 0: **Better than U.S. National Rate** (18.0/1.0)
| | | | | Radiology_DF > 0
| | | | | | Lab_IS <= 0: Worse than U.S. National Rate (5.0)
| | | | | | Lab_IS > 0
| | | | | | | Lab_Molecular <= 0
| | | | | | | | Card_Intravascular_Ultra <= 0
| | | | | | | | | Card_Cath Lab <= 0
| | | | | | | | | | Radiology_DM <= 0
| | | | | | | | | | | Card_IS <= 0: Worse than U.S. National Rate (8.0/1.0)
| | | | | | | | | | | Card_IS > 0
| | | | | | | | | | | | OR_Peri <= 0: Worse than U.S. National Rate (4.0)
| | | | | | | | | | | | OR_Peri > 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | Radiology_DM > 0: No Different than U.S. National Rate (14.0)
| | | | | | | | | Card_Cath Lab > 0
| | | | | | | | | | OR_Peri <= 0
| | | | | | | | | | | OR_Pre <= 0: Worse than U.S. National Rate (3.0)
| | | | | | | | | | | OR_Pre > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | OR_Peri > 0
| | | | | | | | | | | Dictation_SR <= 0: Worse than U.S. National Rate (33.0/1.0)
| | | | | | | | | | | Dictation_SR > 0
| | | | | | | | | | | | Card_CT <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | Card_CT > 0: Worse than U.S. National Rate (4.0)
| | | | | | | | Card_Intravascular_Ultra > 0
| | | | | | | | | OR_Peri <= 0: Worse than U.S. National Rate (4.0)
| | | | | | | | | OR_Peri > 0: No Different than U.S. National Rate (12.0)
| | | | | | | Lab_Molecular > 0: Worse than U.S. National Rate (19.0/2.0)
| | Con_Portal > 0
| | | Anat_Path <= 0
| | | | EMAR <= 0
| | | | | Intensive_Care <= 0: No Different than U.S. National Rate (2.0)
| | | | | Intensive_Care > 0: Worse than U.S. National Rate (18.0/2.0)
| | | | EMAR > 0: No Different than U.S. National Rate (10.0)
| | | Anat_Path > 0
| | | | CPOE <= 0
| | | | | Abstracting <= 0: **Better than U.S. National Rate** (12.0)
| | | | | Abstracting > 0
| | | | | | Lab_Molecular <= 0
| | | | | | | CDSS <= 0
| | | | | | | | OR_Sched <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | OR_Sched > 0: **Better than U.S. National Rate** (31.0)
| | | | | | | CDSS > 0
| | | | | | | | Outcomes and Quality Management <= 0
| | | | | | | | | Card_Cath Lab <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | Card_Cath Lab > 0: Worse than U.S. National Rate (5.0/1.0)
| | | | | | | | Outcomes and Quality Management > 0
| | | | | | | | | EDI <= 0: No Different than U.S. National Rate (10.0)
| | | | | | | | | EDI > 0
| | | | | | | | | | Radiology_Orthopedic <= 0

| | | | | | | | | | | Dictation_SR <= 0
| | | | | | | | | | | | Card_Nuclear_Card <= 0
| | | | | | | | | | | | | Card_Cath Lab <= 0: No Different than U.S. National Rate (13.0)
| | | | | | | | | | | | | Card_Cath Lab > 0
| | | | | | | | | | | | | | Card_Echo <= 0: Worse than U.S. National Rate (4.0/1.0)
| | | | | | | | | | | | | | Card_Echo > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | Card_Nuclear_Card > 0: Worse than U.S. National Rate (3.0)
| | | | | | | | | | | Dictation_SR > 0
| | | | | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | Resp_Care_IS > 0: **Better than U.S. National Rate** (19.0)
| | | | | | | | | | Radiology_Orthopedic > 0
| | | | | | | | | | | Dictation_SR <= 0
| | | | | | | | | | | | Intensive_Care <= 0: No Different than U.S. National Rate (9.0)
| | | | | | | | | | | | Intensive_Care > 0
| | | | | | | | | | | | | Elect_Form <= 0: **Better than U.S. National Rate** (54.0/3.0)
| | | | | | | | | | | | | Elect_Form > 0
| | | | | | | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | Resp_Care_IS > 0
| | | | | | | | | | | | | | | Lab_Outreach <= 0: **Better than U.S. National Rate** (27.0/3.0)
| | | | | | | | | | | | | | | Lab_Outreach > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | Dictation_SR > 0: No Different than U.S. National Rate (13.0)
| | | | | | Lab_Molecular > 0
| | | | | | | Nursing_Doc <= 0
| | | | | | | | Card_IS <= 0: **Better than U.S. National Rate** (8.0)
| | | | | | | | Card_IS > 0: Worse than U.S. National Rate (8.0/1.0)
| | | | | | | Nursing_Doc > 0
| | | | | | | | EDIS <= 0: **Better than U.S. National Rate** (27.0)
| | | | | | | | EDIS > 0
| | | | | | | | | Card_IS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | Card_IS > 0
| | | | | | | | | | In-House_Transcr <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | In-House_Transcr > 0: **Better than U.S. National Rate** (53.0/2.0)
| | | | CPOE > 0
| | | | | Transcr_Remote <= 0
| | | | | | Outcomes and Quality Management <= 0: Worse than U.S. National Rate (5.0)
| | | | | | Outcomes and Quality Management > 0
| | | | | | | EDI <= 0: **Better than U.S. National Rate** (37.0/1.0)
| | | | | | | EDI > 0
| | | | | | | | Dictation_SR <= 0
| | | | | | | | | OR_Post <= 0: Worse than U.S. National Rate (9.0/1.0)
| | | | | | | | | OR_Post > 0
| | | | | | | | | | Nursing_Doc <= 0: Worse than U.S. National Rate (3.0)
| | | | | | | | | | Nursing_Doc > 0
| | | | | | | | | | | Card_IS <= 0: Worse than U.S. National Rate (4.0/1.0)
| | | | | | | | | | | Card_IS > 0: No Different than U.S. National Rate (16.0)
| | | | | | | | Dictation_SR > 0
| | | | | | | | | Card_IS <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | Card_IS > 0
| | | | | | | | | | Doc_Man <= 0: Worse than U.S. National Rate (8.0)
| | | | | | | | | | Doc_Man > 0
| | | | | | | | | | | Obstetrical_Systems <= 0: Worse than U.S. National Rate (5.0)
| | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | Card_CT <= 0
| | | | | | | | | | | | | Card_Nuclear_Card <= 0
| | | | | | | | | | | | | | Card_Cath Lab <= 0: **Better than U.S. National Rate** (8.0)
| | | | | | | | | | | | | | Card_Cath Lab > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | Card_Nuclear_Card > 0: **Better than U.S. National Rate** (20.0)
| | | | | | | | | | | | Card_CT > 0
| | | | | | | | | | | | | Card_Nuclear_Card <= 0: **Better than U.S. National Rate** (13.0)
| | | | | | | | | | | | | Card_Nuclear_Card > 0
| | | | | | | | | | | | | | Phy_Doc <= 0: Worse than U.S. National Rate (11.0/1.0)
| | | | | | | | | | | | | | Phy_Doc > 0: No Different than U.S. National Rate (3.0)
| | | | | Transcr_Remote > 0
| | | | | | Card_Echo <= 0: No Different than U.S. National Rate (8.0)
| | | | | | Card_Echo > 0
| | | | | | | Radiology_DM <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | Radiology_DM > 0: Worse than U.S. National Rate (8.0)

Number of Leaves: 173

26 Portfolios

1. Consumer_Portal, Anatomical_Pathology
2. Blood_Bank, Microbiology, Cardiology_Cath Lab, EMAR, EDIS
3. Blood_Bank, Microbiology, Obstetrical Systems
4. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Dictation_Speech_Recognition
5. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Cardiology_CT
6. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Chart_Tracking, Physician_Portal, Cardiology_Echocardiology
7. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Chart_Tracking, Document_Management
8. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Chart_Tracking, Document_Management, Nursing_Documentation, EMAR
9. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Chart_Tracking, Document_Management, Nursing_Documentation, EMAR, Cardiology_Intravascular_Ultra
10. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Chart_Tracking, Document_Management, EDI, Cardiology_IS, EDIS, SINGLE_SIGN-ON
11. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Chart_Tracking, Document_Management, EDI, Cardiology_IS, EDIS, Radiology_Orthopedic
12. Blood_Bank, Microbiology, Obstetrical Systems, Radiology_MRI, Radiology_Angiography, Pharmacy_Management, Chart_Tracking, Document_Management, EDI, Cardiology_IS, EDIS, Radiology_Orthopedic, Dictation_Speech_Recognition, In-House_Transcription
13. Blood_Bank, Microbiology, Obstetrical Systems, Transcription_Remote_Hosted/ASP, Cardiology_CT
14. Blood_Bank, Microbiology, Obstetrical Systems, CPOE, Dictation_Speech_Recognition
15. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology
16. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, Abstracting, OR_Scheduling

17. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, Abstracting, CDSS, Outcomes and Quality Management, EDI, Dictation_Speech_Recognition, Respitory_Care_IS
18. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, Abstracting, CDSS, Outcomes and Quality Management, EDI, Radiology_Orthopedic, Intensive Care
19. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, Abstracting, CDSS, Outcomes and Quality Management, EDI, Radiology_Orthopedic, Intensive Care, Electronic_Forms
20. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, Abstracting, Lab_Molecular
21. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, Abstracting, Lab_Molecular, Nursing_Documentation
22. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, Abstracting, Lab_Molecular, Nursing_Documentation, EDIS, Cardiology_IS, In-House_Transcription
23. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, CPOE, Outcomes and Quality Management
24. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, CPOE, Outcomes and Quality Management, EDI, Dictation_Speech_Recognition, Cardiology_IS, Document_Management, Obstetrical_Systems
25. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, CPOE, Outcomes and Quality Management, EDI, Dictation_Speech_Recognition, Cardiology_IS, Document_Management, Obstetrical_Systems, Cardiology_Nuclear
26. Blood_Bank, Microbiology, Consumer_Portal, Anatomical_Pathology, CPOE, Outcomes and Quality Management, EDI, Dictation_Speech_Recognition, Cardiology_IS, Document_Management, Obstetrical_Systems, Cardiology_CT

Pneumonia 30 Day Mortality

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Anat_Path <= 0
|   Microbiology <= 0
|   |   Resp_Care_IS <= 0
|   |   |   Dictation <= 0
|   |   |   |   SSO <= 0: No Different than U.S. National Rate (23.0)
|   |   |   |   SSO > 0: Worse than U.S. National Rate (7.0)
|   |   |   Dictation > 0
|   |   |   |   Dictation_SR <= 0
|   |   |   |   |   Intensive_Care <= 0
|   |   |   |   |   |   Abstracting <= 0
|   |   |   |   |   |   |   EDI <= 0: Better than U.S. National Rate (21.0/1.0)
|   |   |   |   |   |   |   EDI > 0: No Different than U.S. National Rate (3.0)
|   |   |   |   |   |   Abstracting > 0
|   |   |   |   |   |   |   Order_Entry <= 0
|   |   |   |   |   |   |   |   Radiology_Angiography <= 0: No Different than U.S. National Rate (10.0)
|   |   |   |   |   |   |   |   Radiology_Angiography > 0
|   |   |   |   |   |   |   |   |   Card_IS <= 0: Better than U.S. National Rate (18.0)
|   |   |   |   |   |   |   |   |   Card_IS > 0
|   |   |   |   |   |   |   |   |   |   Card_Cath Lab <= 0: No Different than U.S. National Rate (2.0)
|   |   |   |   |   |   |   |   |   |   Card_Cath Lab > 0: Better than U.S. National Rate (4.0)
|   |   |   |   |   |   |   Order_Entry > 0
|   |   |   |   |   |   |   |   CPOE <= 0: No Different than U.S. National Rate (24.0)
|   |   |   |   |   |   |   |   CPOE > 0
|   |   |   |   |   |   |   |   |   EDIS <= 0: Better than U.S. National Rate (3.0)
|   |   |   |   |   |   |   |   |   EDIS > 0: No Different than U.S. National Rate (2.0)
|   |   |   |   |   Intensive_Care > 0: No Different than U.S. National Rate (5.0)
|   |   |   |   Dictation_SR > 0: No Different than U.S. National Rate (8.0)
|   |   Resp_Care_IS > 0
|   |   |   Radiology_CT <= 0
|   |   |   |   Nursing_Doc <= 0: Worse than U.S. National Rate (11.0)
|   |   |   |   Nursing_Doc > 0: No Different than U.S. National Rate (4.0)
|   |   |   Radiology_CT > 0: No Different than U.S. National Rate (15.0)
|   Microbiology > 0
|   |   Radiology_Orthopedic <= 0
|   |   |   Radiology_IS <= 0: Worse than U.S. National Rate (15.0/1.0)
|   |   |   Radiology_IS > 0
|   |   |   |   Phy_Doc <= 0
|   |   |   |   |   Nursing_Doc <= 0
|   |   |   |   |   |   Dictation <= 0
|   |   |   |   |   |   |   OR_Pre <= 0: Worse than U.S. National Rate (14.0)
|   |   |   |   |   |   |   OR_Pre > 0: No Different than U.S. National Rate (4.0)
|   |   |   |   |   |   Dictation > 0
|   |   |   |   |   |   |   Radiology_Nuclear <= 0: No Different than U.S. National Rate (21.0)
|   |   |   |   |   |   |   Radiology_Nuclear > 0
|   |   |   |   |   |   |   |   Order_Entry <= 0: Worse than U.S. National Rate (6.0/1.0)
|   |   |   |   |   |   |   |   Order_Entry > 0
|   |   |   |   |   |   |   |   |   Radiology_CR <= 0: Worse than U.S. National Rate (13.0/1.0)
|   |   |   |   |   |   |   |   |   Radiology_CR > 0
|   |   |   |   |   |   |   |   |   |   Transcr_Remote <= 0: No Different than U.S. National Rate (26.0/2.0)
|   |   |   |   |   |   |   |   |   |   Transcr_Remote > 0: Worse than U.S. National Rate (3.0/1.0)
|   |   |   |   |   Nursing_Doc > 0
|   |   |   |   |   |   Card_Nuclear_Card <= 0
|   |   |   |   |   |   |   Dictation <= 0: No Different than U.S. National Rate (7.0/1.0)
|   |   |   |   |   |   |   Dictation > 0
|   |   |   |   |   |   |   |   OR_Peri <= 0
|   |   |   |   |   |   |   |   |   EMAR <= 0
|   |   |   |   |   |   |   |   |   |   Radiology_DM <= 0: No Different than U.S. National Rate (2.0)
|   |   |   |   |   |   |   |   |   |   Radiology_DM > 0: Worse than U.S. National Rate (9.0)
|   |   |   |   |   |   |   |   |   EMAR > 0: No Different than U.S. National Rate (8.0)
|   |   |   |   |   |   |   |   OR_Peri > 0
|   |   |   |   |   |   |   |   |   Chart_Track <= 0
|   |   |   |   |   |   |   |   |   |   Card_IS <= 0: Worse than U.S. National Rate (8.0)
|   |   |   |   |   |   |   |   |   |   Card_IS > 0: No Different than U.S. National Rate (4.0)
|   |   |   |   |   |   |   |   |   Chart_Track > 0
|   |   |   |   |   |   |   |   |   |   Resp_Care_IS <= 0: Worse than U.S. National Rate (43.0/1.0)
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| | | | | | | | | | | Resp_Care_IS > 0
| | | | | | | | | | | | Doc_Man <= 0: Worse than U.S. National Rate (5.0)
| | | | | | | | | | | | Doc_Man > 0: No Different than U.S. National Rate (3.0)
| | | | | | Card_Nuclear_Card > 0: No Different than U.S. National Rate (5.0)
| | | | Phy_Doc > 0
| | | | | OR_Peri <= 0
| | | | | | OR_Post <= 0: No Different than U.S. National Rate (2.0)
| | | | | | OR_Post > 0: Worse than U.S. National Rate (3.0)
| | | | | OR_Peri > 0: No Different than U.S. National Rate (11.0)
| | Radiology_Orthopedic > 0
| | | Con_Portal <= 0
| | | | Card_Nuclear_Card <= 0
| | | | | Lab_Outreach <= 0
| | | | | | EDI <= 0
| | | | | | | Phy_Portal <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | Phy_Portal > 0: **Better than U.S. National Rate** (4.0)
| | | | | | EDI > 0
| | | | | | | Phy_Portal <= 0
| | | | | | | | Radiology_MRI <= 0: Worse than U.S. National Rate (3.0)
| | | | | | | | Radiology_MRI > 0
| | | | | | | | | EMAR <= 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | EMAR > 0
| | | | | | | | | | OR_Peri <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | OR_Peri > 0: Worse than U.S. National Rate (4.0)
| | | | | | | Phy_Portal > 0: No Different than U.S. National Rate (7.0)
| | | | | Lab_Outreach > 0: Worse than U.S. National Rate (6.0/1.0)
| | | | Card_Nuclear_Card > 0: Worse than U.S. National Rate (15.0/1.0)
| | | Con_Portal > 0
| | | | Card_IS <= 0: No Different than U.S. National Rate (5.0/1.0)
| | | | Card_IS > 0: **Better than U.S. National Rate** (13.0)
Anat_Path > 0
| Chart_Track <= 0
| | Dictation_SR <= 0
| | | Radiology_CR <= 0: No Different than U.S. National Rate (2.0)
| | | Radiology_CR > 0
| | | | Resp_Care_IS <= 0
| | | | | CDSS <= 0: Worse than U.S. National Rate (6.0)
| | | | | CDSS > 0
| | | | | | Card_Cath Lab <= 0: No Different than U.S. National Rate (9.0)
| | | | | | Card_Cath Lab > 0: Worse than U.S. National Rate (5.0/1.0)
| | | | Resp_Care_IS > 0: Worse than U.S. National Rate (23.0/2.0)
| | Dictation_SR > 0
| | | Phy_Portal <= 0: No Different than U.S. National Rate (6.0)
| | | Phy_Portal > 0: **Better than U.S. National Rate** (2.0)
| Chart_Track > 0
| | Dictation <= 0
| | | Nursing_Doc <= 0
| | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (10.0)
| | | | Resp_Care_IS > 0: Worse than U.S. National Rate (9.0/1.0)
| | | Nursing_Doc > 0
| | | | Lab_Molecular <= 0
| | | | | CPOE <= 0
| | | | | | Intensive_Care <= 0
| | | | | | | Radiology_Orthopedic <= 0: **Better than U.S. National Rate** (17.0/1.0)
| | | | | | | Radiology_Orthopedic > 0
| | | | | | | | SSO <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | SSO > 0: **Better than U.S. National Rate** (8.0)
| | | | | | Intensive_Care > 0: **Better than U.S. National Rate** (32.0)
| | | | | CPOE > 0
| | | | | | Radiology_Angiography <= 0: **Better than U.S. National Rate** (2.0)
| | | | | | Radiology_Angiography > 0: No Different than U.S. National Rate (3.0)
| | | | Lab_Molecular > 0
| | | | | Card_Echo <= 0: Worse than U.S. National Rate (9.0)
| | | | | Card_Echo > 0: **Better than U.S. National Rate** (7.0)
| | Dictation > 0
| | | Dictation_SR <= 0
| | | | CDSS <= 0
| | | | | Card_Echo <= 0
| | | | | | Intensive_Care <= 0: No Different than U.S. National Rate (12.0)
| | | | | | Intensive_Care > 0

| | | | | | | SSO <= 0: **Better than U.S. National Rate** (5.0)
| | | | | | | SSO > 0: No Different than U.S. National Rate (2.0)
| | | | | Card_Echo > 0: **Better than U.S. National Rate** (6.0)
| | | | CDSS > 0
| | | | | Radiology_DM <= 0
| | | | | | Radiology_IS <= 0
| | | | | | | EMAR <= 0
| | | | | | | | Card_IS <= 0: **Better than U.S. National Rate** (8.0)
| | | | | | | | Card_IS > 0: No Different than U.S. National Rate (2.0)
| | | | | | | EMAR > 0: No Different than U.S. National Rate (7.0)
| | | | | | Radiology_IS > 0
| | | | | | | OR_Peri <= 0
| | | | | | | | Outcomes and Quality Management <= 0: No Different than U.S. National Rate (12.0)
| | | | | | | | Outcomes and Quality Management > 0
| | | | | | | | | Doc_Man <= 0
| | | | | | | | | | OR_Post <= 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | OR_Post > 0: Worse than U.S. National Rate (4.0)
| | | | | | | | | Doc_Man > 0
| | | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | | Nursing_Doc <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | Nursing_Doc > 0
| | | | | | | | | | | | Obstetrical_Systems <= 0: Worse than U.S. National Rate (26.0)
| | | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | | Resp_Care_IS <= 0: Worse than U.S. National Rate (5.0)
| | | | | | | | | | | | | Resp_Care_IS > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | Phy_Doc > 0: Worse than U.S. National Rate (21.0)
| | | | | | | OR_Peri > 0
| | | | | | | | Radiology_Angiography <= 0
| | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (10.0)
| | | | | | | | | Resp_Care_IS > 0
| | | | | | | | | | CPOE <= 0
| | | | | | | | | | | Blood_Bank <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | Blood_Bank > 0
| | | | | | | | | | | | Phy_Portal <= 0: **Better than U.S. National Rate** (18.0/1.0)
| | | | | | | | | | | | Phy_Portal > 0
| | | | | | | | | | | | | Transcr_Remote <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | Transcr_Remote > 0: **Better than U.S. National Rate** (3.0)
| | | | | | | | | | CPOE > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | Radiology_Angiography > 0
| | | | | | | | | Nursing_Doc <= 0
| | | | | | | | | | Elect_Form <= 0
| | | | | | | | | | | EDIS <= 0: Worse than U.S. National Rate (8.0/1.0)
| | | | | | | | | | | EDIS > 0
| | | | | | | | | | | | Outcomes and Quality Management <= 0
| | | | | | | | | | | | | Con_Portal <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | Con_Portal > 0: **Better than U.S. National Rate** (5.0)
| | | | | | | | | | | | Outcomes and Quality Management > 0: No Different than U.S. National Rate (10.0)
| | | | | | | | | | Elect_Form > 0: **Better than U.S. National Rate** (14.0)
| | | | | | | | | Nursing_Doc > 0
| | | | | | | | | | Lab_Outreach <= 0
| | | | | | | | | | | EDI <= 0: No Different than U.S. National Rate (11.0)
| | | | | | | | | | | EDI > 0
| | | | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | | | Order_Entry <= 0: Worse than U.S. National Rate (9.0)
| | | | | | | | | | | | | Order_Entry > 0
| | | | | | | | | | | | | | Card_CT <= 0
| | | | | | | | | | | | | | | EDIS <= 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | EDIS > 0
| | | | | | | | | | | | | | | | Intensive_Care <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | Intensive_Care > 0
| | | | | | | | | | | | | | | | | Resp_Care_IS <= 0: Worse than U.S. National Rate (25.0/1.0)
| | | | | | | | | | | | | | | | | Resp_Care_IS > 0
| | | | | | | | | | | | | | | | | | Doc_Man <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | | | | Doc_Man > 0
| | | | | | | | | | | | | | | | | | | Card_IS <= 0: Worse than U.S. National Rate (8.0)
| | | | | | | | | | | | | | | | | | | Card_IS > 0
| | | | | | | | | | | | | | | | | | | | CPOE <= 0: Worse than U.S. National Rate (8.0)
| | | | | | | | | | | | | | | | | | | | CPOE > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | Card_CT > 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | Con_Portal > 0: No Different than U.S. National Rate (5.0)

| | | | | | | | | | Lab_Outreach > 0
| | | | | | | | | | | Doc_Man <= 0
| | | | | | | | | | | | In-House_Transcr <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | In-House_Transcr > 0
| | | | | | | | | | | | | Card_Cath Lab <= 0: Worse than U.S. National Rate (7.0)
| | | | | | | | | | | | | Card_Cath Lab > 0: **Better than U.S. National Rate** (15.0/4.0)
| | | | | | | | | | | Doc_Man > 0
| | | | | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | | | | Card_CT <= 0
| | | | | | | | | | | | | | Resp_Care_IS <= 0
| | | | | | | | | | | | | | | EMAR <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | EMAR > 0: Worse than U.S. National Rate (12.0)
| | | | | | | | | | | | | | Resp_Care_IS > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | Card_CT > 0: Worse than U.S. National Rate (12.0)
| | | | | | | | | | | | Phy_Doc > 0: No Different than U.S. National Rate (2.0)
| | | | | Radiology_DM > 0
| | | | | | Radiology_Nuclear <= 0
| | | | | | | Transcr_Remote <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | Transcr_Remote > 0: Worse than U.S. National Rate (13.0)
| | | | | | Radiology_Nuclear > 0
| | | | | | | Lab_Molecular <= 0
| | | | | | | | OR_Pre <= 0
| | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | Elect_Form <= 0
| | | | | | | | | | | Doc_Man <= 0: Worse than U.S. National Rate (35.0)
| | | | | | | | | | | Doc_Man > 0
| | | | | | | | | | | | Obstetrical_Systems <= 0: Worse than U.S. National Rate (5.0/1.0)
| | | | | | | | | | | | Obstetrical_Systems > 0: **Better than U.S. National Rate** (14.0)
| | | | | | | | | | Elect_Form > 0
| | | | | | | | | | | OR_Sched <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | OR_Sched > 0
| | | | | | | | | | | | Phy_Portal <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | Phy_Portal > 0
| | | | | | | | | | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | Obstetrical_Systems > 0: Worse than U.S. National Rate (16.0)
| | | | | | | | | Phy_Doc > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | OR_Pre > 0
| | | | | | | | | OR_Sched <= 0
| | | | | | | | | | Card_Cath Lab <= 0
| | | | | | | | | | | Card_IS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | Card_IS > 0: Worse than U.S. National Rate (15.0)
| | | | | | | | | | Card_Cath Lab > 0: **Better than U.S. National Rate** (4.0)
| | | | | | | | | OR_Sched > 0
| | | | | | | | | | OR_Peri <= 0
| | | | | | | | | | | Card_CT <= 0: **Better than U.S. National Rate** (27.0)
| | | | | | | | | | | Card_CT > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | OR_Peri > 0
| | | | | | | | | | | Radiology_IS <= 0
| | | | | | | | | | | | Card_IS <= 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | | | Card_IS > 0: **Better than U.S. National Rate** (10.0/2.0)
| | | | | | | | | | | Radiology_IS > 0
| | | | | | | | | | | | Card_Nuclear_Card <= 0
| | | | | | | | | | | | | Card_Echo <= 0
| | | | | | | | | | | | | | Radiology_DR <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | Radiology_DR > 0
| | | | | | | | | | | | | | | Radiology_Angiography <= 0: **Better than U.S. National Rate** (6.0)
| | | | | | | | | | | | | | | Radiology_Angiography > 0
| | | | | | | | | | | | | | | | EDIS <= 0
| | | | | | | | | | | | | | | | | CPOE <= 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | | | | | | | | CPOE > 0: Worse than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | EDIS > 0
| | | | | | | | | | | | | | | | | Nursing_Doc <= 0
| | | | | | | | | | | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | Resp_Care_IS > 0: Worse than U.S. National Rate (7.0/1.0)
| | | | | | | | | | | | | | | | | Nursing_Doc > 0
| | | | | | | | | | | | | | | | | | EDI <= 0
| | | | | | | | | | | | | | | | | | | EMAR <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | | EMAR > 0: **Better than U.S. National Rate** (13.0)
| | | | | | | | | | | | | | | | | | EDI > 0
| | | | | | | | | | | | | | | | | | | Doc_Man <= 0

| | | | | | | | | | | | | | | | | | | | Card_IS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | | | Card_IS > 0
| | | | | | | | | | | | | | | | | | | | | In-House_Transcr <= 0
| | | | | | | | | | | | | | | | | | | | | | Con_Portal <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | | | | | | | Con_Portal > 0: **Better than U.S. National Rate** (4.0)
| | | | | | | | | | | | | | | | | | | | | In-House_Transcr > 0: **Better than U.S. National Rate** (9.0)
| | | | | | | | | | | | | | | | | | | Doc_Man > 0
| | | | | | | | | | | | | | | | | | | | Blood_Bank <= 0: **Better than U.S. National Rate** (5.0/1.0)
| | | | | | | | | | | | | | | | | | | | Blood_Bank > 0
| | | | | | | | | | | | | | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | | | | | | | | | | | | | Card_Cath Lab <= 0
| | | | | | | | | | | | | | | | | | | | | | | CPOE <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | | | | | | | | | CPOE > 0: Worse than U.S. National Rate (15.0)
| | | | | | | | | | | | | | | | | | | | | | Card_Cath Lab > 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | | | | | | | Phy_Doc > 0
| | | | | | | | | | | | | | | | | | | | | | CPOE <= 0: Worse than U.S. National Rate (11.0/2.0)
| | | | | | | | | | | | | | | | | | | | | | CPOE > 0: No Different than U.S. National Rate (14.0/2.0)
| | | | | | | | | | | | | Card_Echo > 0: No Different than U.S. National Rate (20.0)
| | | | | | | | | | | | Card_Nuclear_Card > 0
| | | | | | | | | | | | | Outcomes and Quality Management <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | Outcomes and Quality Management > 0
| | | | | | | | | | | | | | Elect_Form <= 0
| | | | | | | | | | | | | | | Lab_Outreach <= 0
| | | | | | | | | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | | Resp_Care_IS > 0: Worse than U.S. National Rate (4.0/1.0)
| | | | | | | | | | | | | | | Lab_Outreach > 0: **Better than U.S. National Rate** (8.0)
| | | | | | | | | | | | | | Elect_Form > 0: **Better than U.S. National Rate** (41.0/4.0)
| | | | | | | Lab_Molecular > 0
| | | | | | | | SSO <= 0
| | | | | | | | | Card_IS <= 0: **Better than U.S. National Rate** (7.0)
| | | | | | | | | Card_IS > 0
| | | | | | | | | | Radiology_Orthopedic <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | Radiology_Orthopedic > 0: **Better than U.S. National Rate** (11.0/1.0)
| | | | | | | | SSO > 0: No Different than U.S. National Rate (4.0)
| | | Dictation_SR > 0
| | | | Phy_Doc <= 0
| | | | | Radiology_IS <= 0: **Better than U.S. National Rate** (14.0/1.0)
| | | | | Radiology_IS > 0
| | | | | | CDSS <= 0
| | | | | | | Card_Cath Lab <= 0: Worse than U.S. National Rate (8.0)
| | | | | | | Card_Cath Lab > 0: No Different than U.S. National Rate (2.0)
| | | | | | CDSS > 0
| | | | | | | Card_IS <= 0
| | | | | | | | Microbiology <= 0: **Better than U.S. National Rate** (6.0)
| | | | | | | | Microbiology > 0
| | | | | | | | | Nursing_Doc <= 0
| | | | | | | | | | CPOE <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | CPOE > 0: **Better than U.S. National Rate** (5.0)
| | | | | | | | | Nursing_Doc > 0
| | | | | | | | | | Card_Nuclear_Card <= 0: No Different than U.S. National Rate (33.0)
| | | | | | | | | | Card_Nuclear_Card > 0: Worse than U.S. National Rate (3.0/1.0)
| | | | | | | Card_IS > 0
| | | | | | | | SSO <= 0
| | | | | | | | | Elect_Form <= 0
| | | | | | | | | | Transcr_Remote <= 0
| | | | | | | | | | | In-House_Transcr <= 0
| | | | | | | | | | | | EDIS <= 0: **Better than U.S. National Rate** (5.0)
| | | | | | | | | | | | EDIS > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | In-House_Transcr > 0
| | | | | | | | | | | | EDI <= 0: **Better than U.S. National Rate** (21.0/2.0)
| | | | | | | | | | | | EDI > 0
| | | | | | | | | | | | | Phy_Portal <= 0
| | | | | | | | | | | | | | EMAR <= 0
| | | | | | | | | | | | | | | Intensive_Care <= 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | Intensive_Care > 0: **Better than U.S. National Rate** (12.0)
| | | | | | | | | | | | | | EMAR > 0: Worse than U.S. National Rate (18.0/1.0)
| | | | | | | | | | | | | Phy_Portal > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | Transcr_Remote > 0: Worse than U.S. National Rate (4.0)
| | | | | | | | | Elect_Form > 0
| | | | | | | | | | Doc_Man <= 0: Worse than U.S. National Rate (15.0)

| | | | | | | | | | Doc_Man > 0
| | | | | | | | | | | Phy_Portal <= 0
| | | | | | | | | | | | Obstetrical_Systems <= 0: Worse than U.S. National Rate (14.0/1.0)
| | | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | | Con_Portal <= 0: No Different than U.S. National Rate (11.0)
| | | | | | | | | | | | | Con_Portal > 0: Worse than U.S. National Rate (4.0)
| | | | | | | | | | | Phy_Portal > 0: No Different than U.S. National Rate (8.0)
| | | | | | | | SSO > 0
| | | | | | | | | EDI <= 0
| | | | | | | | | | Phy_Portal <= 0: No Different than U.S. National Rate (9.0)
| | | | | | | | | | Phy_Portal > 0: Worse than U.S. National Rate (9.0/2.0)
| | | | | | | | | EDI > 0
| | | | | | | | | | EDIS <= 0
| | | | | | | | | | | Phy_Portal <= 0: Worse than U.S. National Rate (5.0)
| | | | | | | | | | | Phy_Portal > 0
| | | | | | | | | | | | In-House_Transcr <= 0: **Better than U.S. National Rate** (7.0)
| | | | | | | | | | | | In-House_Transcr > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | EDIS > 0
| | | | | | | | | | | EMAR <= 0: **Better than U.S. National Rate** (39.0/2.0)
| | | | | | | | | | | EMAR > 0
| | | | | | | | | | | | Lab_Outreach <= 0: No Different than U.S. National Rate (8.0)
| | | | | | | | | | | | Lab_Outreach > 0
| | | | | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | Resp_Care_IS > 0: **Better than U.S. National Rate** (13.0)
| | | | | | | | | | | | | Con_Portal > 0: No Different than U.S. National Rate (3.0)
| | | | Phy_Doc > 0
| | | | | Intensive_Care <= 0
| | | | | | CPOE <= 0: No Different than U.S. National Rate (8.0)
| | | | | | CPOE > 0: Worse than U.S. National Rate (3.0)
| | | | | Intensive_Care > 0
| | | | | | Nursing_Doc <= 0: **Better than U.S. National Rate** (7.0)
| | | | | | Nursing_Doc > 0
| | | | | | | EDIS <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | EDIS > 0
| | | | | | | | Radiology_DM <= 0
| | | | | | | | | EDI <= 0: **Better than U.S. National Rate** (2.0)
| | | | | | | | | EDI > 0
| | | | | | | | | | SSO <= 0: No Different than U.S. National Rate (12.0)
| | | | | | | | | | SSO > 0
| | | | | | | | | | | Phy_Portal <= 0: **Better than U.S. National Rate** (6.0)
| | | | | | | | | | | Phy_Portal > 0: No Different than U.S. National Rate (5.0)
| | | | | | | | Radiology_DM > 0
| | | | | | | | | Radiology_DF <= 0
| | | | | | | | | | Phy_Portal <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | Phy_Portal > 0: **Better than U.S. National Rate** (3.0)
| | | | | | | | | Radiology_DF > 0
| | | | | | | | | | EMAR <= 0: **Better than U.S. National Rate** (15.0)
| | | | | | | | | | EMAR > 0
| | | | | | | | | | | Card_CT <= 0
| | | | | | | | | | | | Phy_Portal <= 0
| | | | | | | | | | | | | In-House_Transcr <= 0
| | | | | | | | | | | | | | Card_Cath Lab <= 0: **Better than U.S. National Rate** (13.0)
| | | | | | | | | | | | | | Card_Cath Lab > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | In-House_Transcr > 0: No Different than U.S. National Rate (12.0/2.0)
| | | | | | | | | | | | Phy_Portal > 0: **Better than U.S. National Rate** (21.0/2.0)
| | | | | | | | | | | Card_CT > 0: **Better than U.S. National Rate** (46.0/5.0)

Number of Leaves : 202

49 Portfolios

1. Dictation, Abstracting, Radiology Angiography
2. Dictation, Abstracting, Radiology Angiography, Cardiology_IS, Cardiology_Cath Lab

3. Dictation, Abstracting, Order Entry, CPOE,
4. Microbiology, Radiology_Orthopedic, Physician_Portal
5. Microbiology, Radiology_Orthopedic, Consumer_Portal, Cardiology_IS
6. Anatomical_Pathology, Dictation_Speech_Recognition, Physician_Portal
7. Anatomical_Pathology, Chart_Tracking, Nursing_Documentation
8. Anatomical_Pathology, Chart_Tracking, Nursing_Documentation, Radiology_Orthopedic, SINGLE_SIGN-ON
9. Anatomical_Pathology, Chart_Tracking, Nursing_Documentation, Intensive_Care
10. Anatomical_Pathology, Chart_Tracking, Nursing_Documentation, CPOE
11. Anatomical_Pathology, Chart_Tracking, Nursing_Documentation, Lab_Molecular, Cardiology_Echocardiology
12. Anatomical_Pathology, Chart_Tracking, Dictation, Intensive_Care
13. Anatomical_Pathology, Chart_Tracking, Dictation, Cardiology_Echocardiology
14. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS
15. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_IS, Operating_Room_Peri, Respitory_Care_IS, Blood_Bank
16. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_IS, Operating_Room_Peri, Respitory_Care_IS, Blood_Bank, Physician_Portal, Transcription_Remote_Hosted/ASP
17. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_IS, Operating_Room_Peri, Radiology_Angiography, EDIS, Consumer_Portal
18. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_IS, Operating_Room_Peri, Radiology_Angiography, Electronic_Forms
19. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_IS, Operating_Room_Peri, Radiology_Angiography, Nursing_Documentation, Lab_Outreach, In-House_Transcription, Cardiology_Cath Lab
20. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Document_Management, Obstetrical_Systems
21. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, Cardiology_Cath Lab
22. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling
23. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling, Operating_Room_Peri, Cardiology_IS
24. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling, Operating_Room_Peri, Radiology_IS, Radiology_DR
25. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling, Operating_Room_Peri,

Radiology_IS, Radiology_DR, Radiology_Angiography, EDIS, Nursing_Documentation, EMAR

26. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling, Operating_Room_Peri, Radiology_IS, Radiology_DR, Radiology_Angiography, EDIS, Nursing_Documentation, EDI, Cardiology_IS, Consumer_Portal
27. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling, Operating_Room_Peri, Radiology_IS, Radiology_DR, Radiology_Angiography, EDIS, Nursing_Documentation, EDI, Cardiology_IS, In-House_Transcription
28. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling, Operating_Room_Peri, Radiology_IS, Radiology_DR, Radiology_Angiography, EDIS, Nursing_Documentation, EDI, Document_Management
29. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling, Operating_Room_Peri, Radiology_IS, Cardiology_Nuclear, Outcomes and Quality Management, Lab_Outreach
30. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Operating_Room_Pre, OR_Scheduling, Operating_Room_Peri, Radiology_IS, Cardiology_Nuclear, Outcomes and Quality Management, Electronic_Forms
31. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Lab_Molecular
32. Anatomical_Pathology, Chart_Tracking, Dictation, CDSS, Radiology_DM, Radiology_Nuclear, Lab_Molecular, Cardiology_IS, Radiology_Orthopedic
33. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition
34. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Radiology_IS, CDSS
35. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Radiology_IS, CDSS, Microbiology, CPOE
36. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Radiology_IS, CDSS, Cardiology_IS
37. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Radiology_IS, CDSS, Cardiology_IS, In-House_Trancription
38. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Radiology_IS, CDSS, Cardiology_IS, In-House_Trancription, EDI, Intensive_Care
39. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Radiology_IS, CDSS, Cardiology_IS, SINGLE_SIGN-ON, EDI, Physician_Portal
40. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Radiology_IS, CDSS, Cardiology_IS, SINGLE_SIGN-ON, EDI, EDIS

41. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Radiology_IS, CDSS, Cardiology_IS, SINGLE_SIGN-ON, EDI, EDIS, EMAR, Lab_Outreach, Respitory_Care_IS
42. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Physician_Documentation, Intensive_Care
43. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Physician_Documentation, Intensive_Care, Nursing_Documentation, EDIS
44. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Physician_Documentation, Intensive_Care, Nursing_Documentation, EDIS, EDI, SINGLE_SIGN-ON
45. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Physician_Documentation, Intensive_Care, Nursing_Documentation, EDIS, Radiology_DM, Physician_Portal
46. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Physician_Documentation, Intensive_Care, Nursing_Documentation, EDIS, Radiology_DM, Radiology_DF
47. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Physician_Documentation, Intensive_Care, Nursing_Documentation, EDIS, Radiology_DM, Radiology_DF, EMAR
48. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Physician_Documentation, Intensive_Care, Nursing_Documentation, EDIS, Radiology_DM, Radiology_DF, EMAR, Physician_Portal
49. Anatomical_Pathology, Chart_Tracking, Dictation, Dictation_Speech_Recognition, Physician_Documentation, Intensive_Care, Nursing_Documentation, EDIS, Radiology_DM, Radiology_DF, EMAR, Cardiology_CT

Pneumonia Readmission

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Radiology_Angiography <= 0
|  EDIS <= 0
|  |  Intensive_Care <= 0: No Different than U.S. National Rate (61.0)
|  |  Intensive_Care > 0
|  |  |  CDSS <= 0: Worse than U.S. National Rate (4.0)
|  |  |  CDSS > 0: No Different than U.S. National Rate (8.0)
|  EDIS > 0
|  |  Dictation_SR <= 0
|  |  |  Card_Echo <= 0
|  |  |  |  Elect_Form <= 0
|  |  |  |  |  CPOE <= 0
|  |  |  |  |  |  Radiology_DM <= 0
|  |  |  |  |  |  |  Resp_Care_IS <= 0
|  |  |  |  |  |  |  |  OR_Pre <= 0
|  |  |  |  |  |  |  |  |  Card_IS <= 0
|  |  |  |  |  |  |  |  |  |  Anat_Path <= 0
|  |  |  |  |  |  |  |  |  |  |  Radiology_IS <= 0: Worse than U.S. National Rate (10.0)
|  |  |  |  |  |  |  |  |  |  |  Radiology_IS > 0
|  |  |  |  |  |  |  |  |  |  |  |  Dictation <= 0: Worse than U.S. National Rate (10.0/1.0)
|  |  |  |  |  |  |  |  |  |  |  |  Dictation > 0
|  |  |  |  |  |  |  |  |  |  |  |  |  Microbiology <= 0: Worse than U.S. National Rate (9.0)
|  |  |  |  |  |  |  |  |  |  |  |  |  Microbiology > 0: No Different than U.S. National Rate (13.0)
|  |  |  |  |  |  |  |  |  |  Anat_Path > 0: No Different than U.S. National Rate (4.0)
|  |  |  |  |  |  |  |  |  Card_IS > 0: Worse than U.S. National Rate (20.0/1.0)
|  |  |  |  |  |  |  |  OR_Pre > 0: No Different than U.S. National Rate (14.0)
|  |  |  |  |  |  |  Resp_Care_IS > 0: Worse than U.S. National Rate (50.0/3.0)
|  |  |  |  |  |  Radiology_DM > 0: No Different than U.S. National Rate (5.0)
|  |  |  |  |  CPOE > 0: No Different than U.S. National Rate (10.0)
|  |  |  |  Elect_Form > 0: No Different than U.S. National Rate (23.0)
|  |  |  Card_Echo > 0
|  |  |  |  Radiology_CT <= 0: No Different than U.S. National Rate (5.0)
|  |  |  |  Radiology_CT > 0: Worse than U.S. National Rate (46.0/1.0)
|  |  Dictation_SR > 0: No Different than U.S. National Rate (22.0)
Radiology_Angiography > 0
|  Blood_Bank <= 0
|  |  EDI <= 0
|  |  |  Card_Cath Lab <= 0
|  |  |  |  Pharm_Man <= 0
|  |  |  |  |  Card_IS <= 0: Worse than U.S. National Rate (15.0)
|  |  |  |  |  Card_IS > 0: No Different than U.S. National Rate (3.0)
|  |  |  |  Pharm_Man > 0: No Different than U.S. National Rate (15.0)
|  |  |  Card_Cath Lab > 0: Worse than U.S. National Rate (18.0/1.0)
|  |  EDI > 0: No Different than U.S. National Rate (59.0)
|  Blood_Bank > 0
|  |  CDSS <= 0
|  |  |  Radiology_DR <= 0
|  |  |  |  Card_IS <= 0: Worse than U.S. National Rate (4.0)
|  |  |  |  Card_IS > 0: No Different than U.S. National Rate (2.0)
|  |  |  Radiology_DR > 0: No Different than U.S. National Rate (29.0)
|  |  CDSS > 0
|  |  |  Outcomes and Quality Management <= 0
|  |  |  |  Dictation_SR <= 0
|  |  |  |  |  Nursing_Doc <= 0: No Different than U.S. National Rate (11.0)
|  |  |  |  |  Nursing_Doc > 0
|  |  |  |  |  |  Anat_Path <= 0: No Different than U.S. National Rate (5.0)
|  |  |  |  |  |  Anat_Path > 0
|  |  |  |  |  |  |  SSO <= 0
|  |  |  |  |  |  |  |  Intensive_Care <= 0: Worse than U.S. National Rate (39.0/1.0)
|  |  |  |  |  |  |  |  Intensive_Care > 0
|  |  |  |  |  |  |  |  |  Doc_Man <= 0: Worse than U.S. National Rate (15.0/1.0)
|  |  |  |  |  |  |  |  |  Doc_Man > 0: No Different than U.S. National Rate (6.0)
|  |  |  |  |  |  |  SSO > 0
|  |  |  |  |  |  |  |  CPOE <= 0: No Different than U.S. National Rate (9.0)
|  |  |  |  |  |  |  |  CPOE > 0
|  |  |  |  |  |  |  |  |  Phy_Portal <= 0: No Different than U.S. National Rate (3.0)
|  |  |  |  |  |  |  |  |  Phy_Portal > 0: Worse than U.S. National Rate (3.0)
|  |  |  |  Dictation_SR > 0: No Different than U.S. National Rate (16.0)
```

| | | Outcomes and Quality Management > 0
| | | | Radiology_DR <= 0
| | | | | Radiology_Nuclear <= 0
| | | | | | Card_IS <= 0: Worse than U.S. National Rate (8.0)
| | | | | | Card_IS > 0: No Different than U.S. National Rate (3.0)
| | | | | Radiology_Nuclear > 0: No Different than U.S. National Rate (17.0)
| | | | Radiology_DR > 0
| | | | | Dictation <= 0
| | | | | | Phy_Portal <= 0: No Different than U.S. National Rate (10.0)
| | | | | | Phy_Portal > 0: Worse than U.S. National Rate (18.0/1.0)
| | | | | Dictation > 0
| | | | | | Radiology_DF <= 0
| | | | | | | Card_CT <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | Card_CT > 0: **Better than U.S. National Rate** (38.0)
| | | | | | Radiology_DF > 0
| | | | | | | OR_Post <= 0
| | | | | | | | Con_Portal <= 0
| | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | Resp_Care_IS <= 0
| | | | | | | | | | | Lab_Outreach <= 0
| | | | | | | | | | | | Card_Intravascular_Ultra <= 0
| | | | | | | | | | | | | CPOE <= 0
| | | | | | | | | | | | | | Anat_Path <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | Anat_Path > 0
| | | | | | | | | | | | | | | Card_IS <= 0: Worse than U.S. National Rate (37.0)
| | | | | | | | | | | | | | | Card_IS > 0
| | | | | | | | | | | | | | | | SSO <= 0: Worse than U.S. National Rate (27.0/1.0)
| | | | | | | | | | | | | | | | SSO > 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | CPOE > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | Card_Intravascular_Ultra > 0: Worse than U.S. National Rate (25.0)
| | | | | | | | | | | Lab_Outreach > 0
| | | | | | | | | | | | OR_Peri <= 0: No Different than U.S. National Rate (7.0)
| | | | | | | | | | | | OR_Peri > 0: Worse than U.S. National Rate (7.0)
| | | | | | | | | | Resp_Care_IS > 0
| | | | | | | | | | | Intensive_Care <= 0: Worse than U.S. National Rate (5.0/1.0)
| | | | | | | | | | | Intensive_Care > 0: No Different than U.S. National Rate (7.0)
| | | | | | | | | Phy_Doc > 0: No Different than U.S. National Rate (6.0)
| | | | | | | | Con_Portal > 0
| | | | | | | | | Lab_Molecular <= 0: No Different than U.S. National Rate (20.0)
| | | | | | | | | Lab_Molecular > 0: **Better than U.S. National Rate** (27.0/1.0)
| | | | | | | OR_Post > 0
| | | | | | | | Chart_Track <= 0
| | | | | | | | | Phy_Doc <= 0: **Better than U.S. National Rate** (69.0/1.0)
| | | | | | | | | Phy_Doc > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | Chart_Track > 0
| | | | | | | | | CPOE <= 0
| | | | | | | | | | Anat_Path <= 0
| | | | | | | | | | | Card_Echo <= 0
| | | | | | | | | | | | EDIS <= 0
| | | | | | | | | | | | | Doc_Man <= 0: **Better than U.S. National Rate** (33.0)
| | | | | | | | | | | | | Doc_Man > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | EDIS > 0: No Different than U.S. National Rate (13.0)
| | | | | | | | | | | Card_Echo > 0: **Better than U.S. National Rate** (19.0/1.0)
| | | | | | | | | | Anat_Path > 0
| | | | | | | | | | | SSO <= 0
| | | | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | | | EDI <= 0
| | | | | | | | | | | | | | Elect_Form <= 0
| | | | | | | | | | | | | | | Nursing_Doc <= 0: Worse than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | Nursing_Doc > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | Elect_Form > 0
| | | | | | | | | | | | | | | Obstetrical_Systems <= 0: **Better than U.S. National Rate** (57.0/1.0)
| | | | | | | | | | | | | | | Obstetrical_Systems > 0
| | | | | | | | | | | | | | | | Card_Cath Lab <= 0
| | | | | | | | | | | | | | | | | EDIS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | EDIS > 0: **Better than U.S. National Rate** (23.0)
| | | | | | | | | | | | | | | | Card_Cath Lab > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | EDI > 0
| | | | | | | | | | | | | | Elect_Form <= 0
| | | | | | | | | | | | | | | Card_Echo <= 0

| | | | | | | | | | | | | | | | Intensive_Care <= 0
| | | | | | | | | | | | | | | | | Radiology_DM <= 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | | | | | | Radiology_DM > 0
| | | | | | | | | | | | | | | | | | Nursing_Doc <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | Nursing_Doc > 0: Worse than U.S. National Rate (15.0/1.0)
| | | | | | | | | | | | | | | | Intensive_Care > 0: No Different than U.S. National Rate (17.0)
| | | | | | | | | | | | | | | Card_Echo > 0
| | | | | | | | | | | | | | | | Card_Nuclear_Card <= 0: **<u>Better than U.S. National Rate</u>** (23.0)
| | | | | | | | | | | | | | | | Card_Nuclear_Card > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | Elect_Form > 0
| | | | | | | | | | | | | | | Card_IS <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | | | | Card_IS > 0
| | | | | | | | | | | | | | | | Dictation_SR <= 0
| | | | | | | | | | | | | | | | | Transcr_Remote <= 0: Worse than U.S. National Rate (44.0/2.0)
| | | | | | | | | | | | | | | | | Transcr_Remote > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | Dictation_SR > 0
| | | | | | | | | | | | | | | | | Resp_Care_IS <= 0
| | | | | | | | | | | | | | | | | | Obstetrical_Systems <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | | | Obstetrical_Systems > 0: Worse than U.S. National Rate (14.0)
| | | | | | | | | | | | | | | | | Resp_Care_IS > 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | | Con_Portal > 0: No Different than U.S. National Rate (12.0)
| | | | | | | | | | | SSO > 0
| | | | | | | | | | | | In-House_Transcr <= 0
| | | | | | | | | | | | | EDIS <= 0: Worse than U.S. National Rate (12.0/4.0)
| | | | | | | | | | | | | EDIS > 0: No Different than U.S. National Rate (16.0)
| | | | | | | | | | | | In-House_Transcr > 0
| | | | | | | | | | | | | OR_Peri <= 0: Worse than U.S. National Rate (10.0)
| | | | | | | | | | | | | OR_Peri > 0
| | | | | | | | | | | | | | Card_Nuclear_Card <= 0
| | | | | | | | | | | | | | | Card_IS <= 0
| | | | | | | | | | | | | | | | Resp_Care_IS <= 0
| | | | | | | | | | | | | | | | | Doc_Man <= 0: **<u>Better than U.S. National Rate</u>** (24.0)
| | | | | | | | | | | | | | | | | Doc_Man > 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | Resp_Care_IS > 0: No Different than U.S. National Rate (11.0)
| | | | | | | | | | | | | | | Card_IS > 0
| | | | | | | | | | | | | | | | Radiology_DM <= 0
| | | | | | | | | | | | | | | | | Card_Intravascular_Ultra <= 0
| | | | | | | | | | | | | | | | | | Con_Portal <= 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | | | Con_Portal > 0
| | | | | | | | | | | | | | | | | | | Lab_Molecular <= 0
| | | | | | | | | | | | | | | | | | | | Card_Echo <= 0: **<u>Better than U.S. National Rate</u>** (21.0)
| | | | | | | | | | | | | | | | | | | | Card_Echo > 0: No Different than U.S. National Rate (6.0)
| | | | | | | | | | | | | | | | | | | Lab_Molecular > 0: **<u>Better than U.S. National Rate</u>** (33.0)
| | | | | | | | | | | | | | | | | Card_Intravascular_Ultra > 0: **<u>Better than U.S. National Rate</u>** (79.0)
| | | | | | | | | | | | | | | | Radiology_DM > 0
| | | | | | | | | | | | | | | | | Card_Echo <= 0
| | | | | | | | | | | | | | | | | | Dictation_SR <= 0: **<u>Better than U.S. National Rate</u>** (24.0)
| | | | | | | | | | | | | | | | | | Dictation_SR > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | | | | Card_Echo > 0: No Different than U.S. National Rate (11.0)
| | | | | | | | | | | | | | Card_Nuclear_Card > 0
| | | | | | | | | | | | | | | Lab_Molecular <= 0
| | | | | | | | | | | | | | | | Resp_Care_IS <= 0: No Different than U.S. National Rate (2.0)
| | | | | | | | | | | | | | | | Resp_Care_IS > 0: Worse than U.S. National Rate (16.0/1.0)
| | | | | | | | | | | | | | | Lab_Molecular > 0
| | | | | | | | | | | | | | | | Dictation_SR <= 0: **<u>Better than U.S. National Rate</u>** (35.0)
| | | | | | | | | | | | | | | | Dictation_SR > 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | CPOE > 0
| | | | | | | | | | Con_Portal <= 0
| | | | | | | | | | | EDIS <= 0: Worse than U.S. National Rate (18.0)
| | | | | | | | | | | EDIS > 0
| | | | | | | | | | | | Transcr_Remote <= 0
| | | | | | | | | | | | | SSO <= 0
| | | | | | | | | | | | | | Dictation_SR <= 0
| | | | | | | | | | | | | | | Card_Echo <= 0
| | | | | | | | | | | | | | | | OR_Sched <= 0: Worse than U.S. National Rate (11.0)
| | | | | | | | | | | | | | | | OR_Sched > 0: No Different than U.S. National Rate (13.0)
| | | | | | | | | | | | | | | Card_Echo > 0: Worse than U.S. National Rate (56.0/1.0)
| | | | | | | | | | | | | | Dictation_SR > 0
| | | | | | | | | | | | | | | Phy_Doc <= 0
| | | | | | | | | | | | | | | | Radiology_Orthopedic <= 0: Worse than U.S. National Rate (9.0/1.0)

```
| | | | | | | | | | | | | | | |  Radiology_Orthopedic > 0: No Different than U.S. National Rate (3.0)
| | | | | | | | | | | | | | |  Phy_Doc > 0: No Different than U.S. National Rate (13.0)
| | | | | | | | | | | | |  SSO > 0: No Different than U.S. National Rate (5.0)
| | | | | | | | | | | |  Transcr_Remote > 0: No Different than U.S. National Rate (9.0)
| | | | | | | | | |  Con_Portal > 0
| | | | | | | | | | |  Lab_Molecular <= 0
| | | | | | | | | | | |  Card_Echo <= 0: No Different than U.S. National Rate (14.0)
| | | | | | | | | | | |  Card_Echo > 0
| | | | | | | | | | | | |  Phy_Portal <= 0: No Different than U.S. National Rate (4.0)
| | | | | | | | | | | | |  Phy_Portal > 0: Better than U.S. National Rate (78.0/2.0)
| | | | | | | | | | |  Lab_Molecular > 0
| | | | | | | | | | | |  In-House_Transcr <= 0: Worse than U.S. National Rate (25.0/1.0)
| | | | | | | | | | | |  In-House_Transcr > 0: No Different than U.S. National Rate (5.0)
```

Number of Leaves: 111

15 Portfolios

1. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Cardiology_CT
2. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Consumer_Portal, Lab_Molecular
3. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post
4. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking
5. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Cardiology_Echocardiology
6. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, Electronic_Forms
7. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, Electronic_Forms, Obstetrical_Systems, EDIS
8. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, EDI, Cardiology_Echocardiology
9. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, SINGLE_SIGN-ON, In-House_Transcription, Operating_Room_Peri
10. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, SINGLE_SIGN-ON, In-House_Transcription, Operating_Room_Peri, Cardiology_IS, Consumer_Portal,

11. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, SINGLE_SIGN-ON, In-House_Transcription, Operating_Room_Peri, Cardiology_IS, Consumer_Portal, Lab_Molecular
12. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, SINGLE_SIGN-ON, In-House_Transcription, Operating_Room_Peri, Cardiology_IS, Cardiology_Intravascular_Ultra
13. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, SINGLE_SIGN-ON, In-House_Transcription, Operating_Room_Peri, Cardiology_IS, Radiology_DM
14. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, Anatomical_Pathology, SINGLE_SIGN-ON, In-House_Transcription, Operating_Room_Peri, Cardiology_Nuclear, Lab_Molecular
15. Radiology_Angiography, Blood_Bank, CDSS, Outcomes and Quality Management, Radiology_DR, Dictation, Radiology_DF, Operating_Room_Post, Chart_Tracking, CPOE, Consumer_Portal, Cardiology_Echocardiology, Physician_Portal

APPENDIX B: SQL CODE TO JOIN DATASETS

Code to Join HIMSS and Medicare Datasets

```
drop Table [Dec_12].dbo.[HaentityID_MAX_applications]
 go
 select  [HAEntityId],
 MAX([Ambulatory EMR]) as [Ambulatory EMR],
MAX([Ambulatory Laboratory]) as [Ambulatory Laboratory],
MAX([Ambulatory PACS]) as [Ambulatory PACS],
MAX([Ambulatory Pharmacy]) as [Ambulatory Pharmacy],
MAX([Ambulatory Radiology]) as [Ambulatory Radiology],
MAX([Practice Management]) as [Practice Management],
MAX([Cardiology - Cath Lab]) as [Cardiology - Cath Lab],
MAX([Cardiology - CT (Computerized Tomography)]) as [Cardiology - CT (Computerized Tomography)],
MAX([Cardiology - Echocardiology]) as [Cardiology - Echocardiology],
MAX([Cardiology - Intravascular Ultrasound]) as [Cardiology - Intravascular Ultrasound],
MAX([Cardiology - Nuclear Cardiology]) as [Cardiology - Nuclear Cardiology],
MAX([Cardiology Information System]) as [Cardiology Information System],
MAX([Emergency Department Information System (EDIS)]) as [Emergency Department Information System
        (EDIS)],
MAX([Operating Room (Surgery) - Peri-Operative]) as [Operating Room (Surgery) - Peri-Operative],
MAX([Operating Room (Surgery) - Post-Operative]) as [Operating Room (Surgery) - Post-Operative],
MAX([Operating Room (Surgery) - Pre-Operative]) as [Operating Room (Surgery) - Pre-Operative],
MAX([OR Scheduling]) as [OR Scheduling],
MAX([Respiratory Care Information System]) as [Respiratory Care Information System],
MAX([Clinical Data Repository]) as [Clinical Data Repository],
MAX([Clinical Decision Support System (CDSS)]) as [Clinical Decision Support System (CDSS)],
MAX([Computerized Practitioner Order Entry (CPOE)]) as [Computerized Practitioner Order Entry (CPOE)],
MAX([Order Entry (Includes Order Communications)]) as [Order Entry (Includes Order Communications)],
MAX([Physician Documentation]) as [Physician Documentation],
MAX([Physician Portal]) as [Physician Portal],
MAX([Budgeting]) as [Budgeting],
MAX([Business Intelligence]) as [Business Intelligence],
MAX([Contract Management]) as [Contract Management],
MAX([Cost Accounting]) as [Cost Accounting],
MAX([Data Warehousing/Mining - Financial]) as [Data Warehousing/Mining - Financial],
MAX([Executive Information System]) as [Executive Information System],
MAX([Financial Modeling]) as [Financial Modeling],
MAX([Accounts Payable]) as [Accounts Payable],
MAX([General Ledger]) as [General Ledger],
MAX([Abstracting]) as [Abstracting],
MAX([Chart Deficiency]) as [Chart Deficiency],
MAX([Chart Tracking/Locator]) as [Chart Tracking/Locator],
MAX([Dictation]) as [Dictation],
MAX([Dictation with Speech Recognition]) as [Dictation with Speech Recognition],
MAX([Encoder]) as [Encoder],
MAX([In-House Transcription]) as [In-House Transcription],
MAX([Transcription - Remote Hosted/ASP]) as [Transcription - Remote Hosted/ASP],
MAX([Document Management]) as [Document Management],
MAX([Electronic Forms Management]) as [Electronic Forms Management],
MAX([Home Health Administrative]) as [Home Health Administrative],
```

```
MAX([Home Health Clinical]) as [Home Health Clinical],
MAX([Benefits Administration]) as [Benefits Administration],
MAX([Payroll]) as [Payroll],
MAX([Personnel Management]) as [Personnel Management],
MAX([Time and Attendance]) as [Time and Attendance],
MAX([Browser]) as [Browser],
MAX([DBMS]) as [DBMS],
MAX([Email]) as [Email],
MAX([Interface Engines]) as [Interface Engines],
MAX([Single Sign-On]) as [Single Sign-On],
MAX([Consumer Portal]) as [Consumer Portal],
MAX([Web Development Tool]) as [Web Development Tool],
MAX([Disaster Recovery System]) as [Disaster Recovery System],
MAX([Encryption]) as [Encryption],
MAX([Firewall]) as [Firewall],
MAX([Spam/Spyware Filter]) as [Spam/Spyware Filter],
MAX([Anatomical Pathology]) as [Anatomical Pathology],
MAX([Blood Bank]) as [Blood Bank],
MAX([Laboratory Information System]) as [Laboratory Information System],
MAX([Microbiology]) as [Microbiology],
MAX([Laboratory - Molecular Diagnostics]) as [Laboratory - Molecular Diagnostics],
MAX([Laboratory - Outreach Services]) as [Laboratory - Outreach Services],
MAX([Electronic Medication Administration Record (EMAR)]) as [Electronic Medication Administration
        Record (EMAR)],
MAX([Intensive Care]) as [Intensive Care],
MAX([Nurse Acuity]) as [Nurse Acuity],
MAX([Nurse Staffing/Scheduling]) as [Nurse Staffing/Scheduling],
MAX([Nursing Documentation]) as [Nursing Documentation],
MAX([Obstetrical Systems (Labor and Delivery)]) as [Obstetrical Systems (Labor and Delivery)],
MAX([Pharmacy Management System]) as [Pharmacy Management System],
MAX([Radiology - Angiography]) as [Radiology - Angiography],
MAX([Radiology - CR (Computed Radiography)]) as [Radiology - CR (Computed Radiography)],
MAX([Radiology - CT (Computerized Tomography)]) as [Radiology - CT (Computerized Tomography)],
MAX([Radiology - DF (Digital Fluoroscopy)]) as [Radiology - DF (Digital Fluoroscopy)],
MAX([Radiology - Digital Mammography]) as [Radiology - Digital Mammography],
MAX([Radiology - Digital Radiography (Digital Radiography)]) as [Radiology - Digital Radiography (Digital
        Radiography)],
MAX([Radiology - MRI (Magnetic Resonance Imaging)]) as [Radiology - MRI (Magnetic Resonance
        Imaging)],
MAX([Radiology - Nuclear Medicine]) as [Radiology - Nuclear Medicine],
MAX([Radiology - Orthopedic]) as [Radiology - Orthopedic],
MAX([Radiology - US (Ultrasound)]) as [Radiology - US (Ultrasound)],
MAX([Radiology Information System]) as [Radiology Information System],
MAX([ADT/Registration]) as [ADT/Registration],
MAX([Bed Management]) as [Bed Management],
MAX([Credit/Collections]) as [Credit/Collections],
MAX([Electronic Data Interchange (EDI) - Clearing House Vendor]) as [Electronic Data Interchange (EDI) -
        Clearing House Vendor],
MAX([Enterprise Master Person Index (EMPI)]) as [Enterprise Master Person Index (EMPI)],
MAX([Patient Billing]) as [Patient Billing],
MAX([Patient Scheduling]) as [Patient Scheduling],
MAX([Medical Necessity Checking Content]) as [Medical Necessity Checking Content],
MAX([Enterprise Resource Planning]) as [Enterprise Resource Planning],
MAX([Materials Management]) as [Materials Management],
MAX([Case Mix Management]) as [Case Mix Management],
MAX([Data Warehousing/Mining - Clinical]) as [Data Warehousing/Mining - Clinical],
```

```
MAX([Outcomes and Quality Management]) as [Outcomes and Quality Management]
/*[Heart Attack Death (Mortality) Rates]
    ,[Heart Attack Readmission Rates]
    ,[Heart Failure Mortality]
    ,[Heart Failure Readmission]
    ,[Pneumonia 30-day Mortality]
    ,[Pneumonia Readmission] */
    into [Dec_12].dbo.[HaentityID_MAX_applications]
 from
 (SELECT
    [HAEntityId]
    ,
    [Facility Name],

case when application = 'Ambulatory EMR' then 1 else 0 end as [Ambulatory EMR],
case when application = 'Ambulatory Laboratory' then 1 else 0 end as [Ambulatory Laboratory],
case when application = 'Ambulatory PACS' then 1 else 0 end as [Ambulatory PACS],
case when application = 'Ambulatory Pharmacy' then 1 else 0 end as [Ambulatory Pharmacy],
case when application = 'Ambulatory Radiology' then 1 else 0 end as [Ambulatory Radiology],
case when application = 'Practice Management' then 1 else 0 end as [Practice Management],
case when application = 'Cardiology - Cath Lab' then 1 else 0 end as [Cardiology - Cath Lab],
case when application = 'Cardiology - CT (Computerized Tomography)' then 1 else 0 end as [Cardiology - CT
        (Computerized Tomography)],
case when application = 'Cardiology - Echocardiology' then 1 else 0 end as [Cardiology - Echocardiology],
case when application = 'Cardiology - Intravascular Ultrasound' then 1 else 0 end as [Cardiology - Intravascular
        Ultrasound],
case when application = 'Cardiology - Nuclear Cardiology' then 1 else 0 end as [Cardiology - Nuclear
        Cardiology],
case when application = 'Cardiology Information System' then 1 else 0 end as [Cardiology Information System],
case when application = 'Emergency Department Information System (EDIS)' then 1 else 0 end as [Emergency
        Department Information System (EDIS)],
case when application = 'Operating Room (Surgery) - Peri-Operative' then 1 else 0 end as [Operating Room
        (Surgery) - Peri-Operative],
case when application = 'Operating Room (Surgery) - Post-Operative' then 1 else 0 end as [Operating Room
        (Surgery) - Post-Operative],
case when application = 'Operating Room (Surgery) - Pre-Operative' then 1 else 0 end as [Operating Room
        (Surgery) - Pre-Operative],
case when application = 'OR Scheduling' then 1 else 0 end as [OR Scheduling],
case when application = 'Respiratory Care Information System' then 1 else 0 end as [Respiratory Care
        Information System],
case when application = 'Clinical Data Repository' then 1 else 0 end as [Clinical Data Repository],
case when application = 'Clinical Decision Support System (CDSS)' then 1 else 0 end as [Clinical Decision
        Support System (CDSS)],
case when application = 'Computerized Practitioner Order Entry (CPOE)' then 1 else 0 end as [Computerized
        Practitioner Order Entry (CPOE)],
case when application = 'Order Entry (Includes Order Communications)' then 1 else 0 end as [Order Entry
        (Includes Order Communications)],
case when application = 'Physician Documentation' then 1 else 0 end as [Physician Documentation],
case when application = 'Physician Portal' then 1 else 0 end as [Physician Portal],
case when application = 'Budgeting' then 1 else 0 end as [Budgeting],
case when application = 'Business Intelligence' then 1 else 0 end as [Business Intelligence],
case when application = 'Contract Management' then 1 else 0 end as [Contract Management],
case when application = 'Cost Accounting' then 1 else 0 end as [Cost Accounting],
case when application = 'Data Warehousing/Mining - Financial' then 1 else 0 end as [Data Warehousing/Mining
        - Financial],
case when application = 'Executive Information System' then 1 else 0 end as [Executive Information System],
```

```
case when application = 'Financial Modeling' then 1 else 0 end as [Financial Modeling],
case when application = 'Accounts Payable' then 1 else 0 end as [Accounts Payable],
case when application = 'General Ledger' then 1 else 0 end as [General Ledger],
case when application = 'Abstracting' then 1 else 0 end as [Abstracting],
case when application = 'Chart Deficiency' then 1 else 0 end as [Chart Deficiency],
case when application = 'Chart Tracking/Locator' then 1 else 0 end as [Chart Tracking/Locator],
case when application = 'Dictation' then 1 else 0 end as [Dictation],
case when application = 'Dictation with Speech Recognition' then 1 else 0 end as [Dictation with Speech
        Recognition],
case when application = 'Encoder' then 1 else 0 end as [Encoder],
case when application = 'In-House Transcription' then 1 else 0 end as [In-House Transcription],
case when application = 'Transcription - Remote Hosted/ASP' then 1 else 0 end as [Transcription - Remote
        Hosted/ASP],
case when application = 'Document Management' then 1 else 0 end as [Document Management],
case when application = 'Electronic Forms Management' then 1 else 0 end as [Electronic Forms Management],
case when application = 'Home Health Administrative' then 1 else 0 end as [Home Health Administrative],
case when application = 'Home Health Clinical' then 1 else 0 end as [Home Health Clinical],
case when application = 'Benefits Administration' then 1 else 0 end as [Benefits Administration],
case when application = 'Payroll' then 1 else 0 end as [Payroll],
case when application = 'Personnel Management' then 1 else 0 end as [Personnel Management],
case when application = 'Time and Attendance' then 1 else 0 end as [Time and Attendance],
case when application = 'Browser' then 1 else 0 end as [Browser],
case when application = 'DBMS' then 1 else 0 end as [DBMS],
case when application = 'Email' then 1 else 0 end as [Email],
case when application = 'Interface Engines' then 1 else 0 end as [Interface Engines],
case when application = 'Single Sign-On' then 1 else 0 end as [Single Sign-On],
case when application = 'Consumer Portal' then 1 else 0 end as [Consumer Portal],
case when application = 'Web Development Tool' then 1 else 0 end as [Web Development Tool],
case when application = 'Disaster Recovery System' then 1 else 0 end as [Disaster Recovery System],
case when application = 'Encryption' then 1 else 0 end as [Encryption],
case when application = 'Firewall' then 1 else 0 end as [Firewall],
case when application = 'Spam/Spyware Filter' then 1 else 0 end as [Spam/Spyware Filter],
case when application = 'Anatomical Pathology' then 1 else 0 end as [Anatomical Pathology],
case when application = 'Blood Bank' then 1 else 0 end as [Blood Bank],
case when application = 'Laboratory Information System' then 1 else 0 end as [Laboratory Information System],
case when application = 'Microbiology' then 1 else 0 end as [Microbiology],
case when application = 'Laboratory - Molecular Diagnostics' then 1 else 0 end as [Laboratory - Molecular
        Diagnostics],
case when application = 'Laboratory - Outreach Services' then 1 else 0 end as [Laboratory - Outreach Services],
case when application = 'Electronic Medication Administration Record (EMAR)' then 1 else 0 end as [Electronic
        Medication Administration Record (EMAR)],
case when application = 'Intensive Care' then 1 else 0 end as [Intensive Care],
case when application = 'Nurse Acuity' then 1 else 0 end as [Nurse Acuity],
case when application = 'Nurse Staffing/Scheduling' then 1 else 0 end as [Nurse Staffing/Scheduling],
case when application = 'Nursing Documentation' then 1 else 0 end as [Nursing Documentation],
case when application = 'Obstetrical Systems (Labor and Delivery)' then 1 else 0 end as [Obstetrical Systems
        (Labor and Delivery)],
case when application = 'Pharmacy Management System' then 1 else 0 end as [Pharmacy Management System],
case when application = 'Radiology - Angiography' then 1 else 0 end as [Radiology - Angiography],
case when application = 'Radiology - CR (Computed Radiography)' then 1 else 0 end as [Radiology - CR
        (Computed Radiography)],
case when application = 'Radiology - CT (Computerized Tomography)' then 1 else 0 end as [Radiology - CT
        (Computerized Tomography)],
case when application = 'Radiology - DF (Digital Fluoroscopy)' then 1 else 0 end as [Radiology - DF (Digital
        Fluoroscopy)],
```

```
case when application = 'Radiology - Digital Mammography' then 1 else 0 end as [Radiology - Digital
        Mammography],
case when application = 'Radiology - Digital Radiography (Digital Radiography)' then 1 else 0 end as [Radiology
        - Digital Radiography (Digital Radiography)],
case when application = 'Radiology - MRI (Magnetic Resonance Imaging)' then 1 else 0 end as [Radiology -
        MRI (Magnetic Resonance Imaging)],
case when application = 'Radiology - Nuclear Medicine' then 1 else 0 end as [Radiology - Nuclear Medicine],
case when application = 'Radiology - Orthopedic' then 1 else 0 end as [Radiology - Orthopedic],
case when application = 'Radiology - US (Ultrasound)' then 1 else 0 end as [Radiology - US (Ultrasound)],
case when application = 'Radiology Information System' then 1 else 0 end as [Radiology Information System],
case when application = 'ADT/Registration' then 1 else 0 end as [ADT/Registration],
case when application = 'Bed Management' then 1 else 0 end as [Bed Management],
case when application = 'Credit/Collections' then 1 else 0 end as [Credit/Collections],
case when application = 'Electronic Data Interchange (EDI) - Clearing House Vendor' then 1 else 0 end as
        [Electronic Data Interchange (EDI) - Clearing House Vendor],
case when application = 'Enterprise Master Person Index (EMPI)' then 1 else 0 end as [Enterprise Master Person
        Index (EMPI)],
case when application = 'Patient Billing' then 1 else 0 end as [Patient Billing],
case when application = 'Patient Scheduling' then 1 else 0 end as [Patient Scheduling],
case when application = 'Medical Necessity Checking Content' then 1 else 0 end as [Medical Necessity Checking
        Content],
case when application = 'Enterprise Resource Planning' then 1 else 0 end as [Enterprise Resource Planning],
case when application = 'Materials Management' then 1 else 0 end as [Materials Management],
case when application = 'Case Mix Management' then 1 else 0 end as [Case Mix Management],
case when application = 'Data Warehousing/Mining - Clinical' then 1 else 0 end as [Data Warehousing/Mining -
        Clinical],
case when application = 'Outcomes and Quality Management' then 1 else 0 end as [Outcomes and Quality
        Management]
/* ,[How do patients rate the hospital overall?]
    ,[Did Doctors Communicate]
    ,[Did Nurses Communicate]
    ,[Receive help quickly from staff]
    ,[How often did staff explain about medicines before giving them t]
    ,[How often was patients pain well controlled?]
    ,[Were patients given information about what to do during their re]
    ,[Would patients recommend the hospital to friends and family?]
    ,[Heart Attack Death (Mortality) Rates]
    ,[Heart Attack Readmission Rates]
    ,[Heart Failure Mortality]
    ,[Heart Failure Readmission]
    ,[Pneumonia 30-day Mortality]
    ,[Pneumonia Readmission]
    ,[F23]*/
```

Code to Incorporate Control Variables

```
SELECT  distinct  /* a.[AppId]
     ,a.[SurveyId]
      , */

      a.[HAEntityId]
      , c.[Provider Number]
     /* ,a.[Facility Name] */
      ,b.Name
     , b.state
     , b.type
     , b.nofbeds
     , hh.[Hospital Ownership]
      , [Ambulatory EMR],
[Ambulatory Laboratory],
[Ambulatory PACS],
[Ambulatory Pharmacy],
[Ambulatory Radiology],
[Practice Management],
[Cardiology - Cath Lab],
[Cardiology - CT (Computerized Tomography)],
[Cardiology - Echocardiology],
[Cardiology - Intravascular Ultrasound],
[Cardiology - Nuclear Cardiology],
[Cardiology Information System],
[Emergency Department Information System (EDIS)],
[Operating Room (Surgery) - Peri-Operative],
[Operating Room (Surgery) - Post-Operative],
[Operating Room (Surgery) - Pre-Operative],
[OR Scheduling],
[Respiratory Care Information System],
[Clinical Data Repository],
[Clinical Decision Support System (CDSS)],
[Computerized Practitioner Order Entry (CPOE)],
[Order Entry (Includes Order Communications)],
[Physician Documentation],
[Physician Portal],
[Budgeting],
[Business Intelligence],
[Contract Management],
[Cost Accounting],
[Data Warehousing/Mining - Financial],
[Executive Information System],
[Financial Modeling],
[Accounts Payable],
[General Ledger],
[Abstracting],
[Chart Deficiency],
[Chart Tracking/Locator],
[Dictation],
[Dictation with Speech Recognition],
[Encoder],
[In-House Transcription],
[Transcription - Remote Hosted/ASP],
```

[Document Management],
[Electronic Forms Management],
[Home Health Administrative],
[Home Health Clinical],
[Benefits Administration],
[Payroll],
[Personnel Management],
[Time and Attendance],
[Browser],
[DBMS],
[Email],
[Interface Engines],
[Single Sign-On],
[Consumer Portal],
[Web Development Tool],
[Disaster Recovery System],
[Encryption],
[Firewall],
[Spam/Spyware Filter],
[Anatomical Pathology],
[Blood Bank],
[Laboratory Information System],
[Microbiology],
[Laboratory - Molecular Diagnostics],
[Laboratory - Outreach Services],
[Electronic Medication Administration Record (EMAR)],
[Intensive Care],
[Nurse Acuity],
[Nurse Staffing/Scheduling],
[Nursing Documentation],
[Obstetrical Systems (Labor and Delivery)],
[Pharmacy Management System],
[Radiology - Angiography],
[Radiology - CR (Computed Radiography)],
[Radiology - CT (Computerized Tomography)],
[Radiology - DF (Digital Fluoroscopy)],
[Radiology - Digital Mammography],
[Radiology - Digital Radiography (Digital Radiography)],
[Radiology - MRI (Magnetic Resonance Imaging)],
[Radiology - Nuclear Medicine],
[Radiology - Orthopedic],
[Radiology - US (Ultrasound)],
[Radiology Information System],
[ADT/Registration],
[Bed Management],
[Credit/Collections],
[Electronic Data Interchange (EDI) - Clearing House Vendor],
[Enterprise Master Person Index (EMPI)],
[Patient Billing],
[Patient Scheduling],
[Medical Necessity Checking Content],
[Enterprise Resource Planning],
[Materials Management],
[Case Mix Management],
[Data Warehousing/Mining - Clinical],
[Outcomes and Quality Management],

[Ambulatory EMR] +
[Ambulatory Laboratory] +
[Ambulatory PACS] +
[Ambulatory Pharmacy] +
[Ambulatory Radiology] +
[Practice Management] +
[Cardiology - Cath Lab] +
[Cardiology - CT (Computerized Tomography)] +
[Cardiology - Echocardiology] +
[Cardiology - Intravascular Ultrasound] +
[Cardiology - Nuclear Cardiology] +
[Cardiology Information System] +
[Emergency Department Information System (EDIS)] +
[Operating Room (Surgery) - Peri-Operative] +
[Operating Room (Surgery) - Post-Operative] +
[Operating Room (Surgery) - Pre-Operative] +
[OR Scheduling] +
[Respiratory Care Information System] +
[Clinical Data Repository] +
[Clinical Decision Support System (CDSS)] +
[Computerized Practitioner Order Entry (CPOE)] +
[Order Entry (Includes Order Communications)] +
[Physician Documentation] +
[Physician Portal] +
[Budgeting] +
[Business Intelligence] +
[Contract Management] +
[Cost Accounting] +
[Data Warehousing/Mining - Financial] +
[Executive Information System] +
[Financial Modeling] +
[Accounts Payable] +
[General Ledger] +
[Abstracting] +
[Chart Deficiency] +
[Chart Tracking/Locator] +
[Dictation] +
[Dictation with Speech Recognition] +
[Encoder] +
[In-House Transcription] +
[Transcription - Remote Hosted/ASP] +
[Document Management] +
[Electronic Forms Management] +
[Home Health Administrative] +
[Home Health Clinical] +
[Benefits Administration] +
[Payroll] +
[Personnel Management] +
[Time and Attendance] +
[Browser] +
[DBMS] +
[Email] +
[Interface Engines] +
[Single Sign-On] +
[Consumer Portal] +
[Web Development Tool] +

```
[Disaster Recovery System] +
[Encryption] +
[Firewall] +
[Spam/Spyware Filter] +
[Anatomical Pathology] +
[Blood Bank] +
[Laboratory Information System] +
[Microbiology] +
[Laboratory - Molecular Diagnostics] +
[Laboratory - Outreach Services] +
[Electronic Medication Administration Record (EMAR)] +
[Intensive Care] +
[Nurse Acuity] +
[Nurse Staffing/Scheduling] +
[Nursing Documentation] +
[Obstetrical Systems (Labor and Delivery)] +
[Pharmacy Management System] +
[Radiology - Angiography] +
[Radiology - CR (Computed Radiography)] +
[Radiology - CT (Computerized Tomography)] +
[Radiology - DF (Digital Fluoroscopy)] +
[Radiology - Digital Mammography] +
[Radiology - Digital Radiography (Digital Radiography)] +
[Radiology - MRI (Magnetic Resonance Imaging)] +
[Radiology - Nuclear Medicine] +
[Radiology - Orthopedic] +
[Radiology - US (Ultrasound)] +
[Radiology Information System] +
[ADT/Registration] +
[Bed Management] +
[Credit/Collections] +
[Electronic Data Interchange (EDI) - Clearing House Vendor] +
[Enterprise Master Person Index (EMPI)] +
[Patient Billing] +
[Patient Scheduling] +
[Medical Necessity Checking Content] +
[Enterprise Resource Planning] +
[Materials Management] +
[Case Mix Management] +
[Data Warehousing/Mining - Clinical] +
[Outcomes and Quality Management] as [Total Apps],
    /*,a.[ApplicationId]
    ,a.[Application]
    ,a.[CategoryId]
    ,a.[Category]
    ,a.[How do patients rate the hospital overall?]
    ,a.[Did Doctors Communicate]
    ,a.[Did Nurses Communicate]
    ,a.[Receive help quickly from staff]
    ,a.[How often did staff explain about medicines before giving them t]
    ,a.[How often was patients pain well controlled?]
    ,a.[Were patients given information about what to do during their re]
    ,a.[Would patients recommend the hospital to friends and family?]
    ,*/
    c.[Heart Attack Death (Mortality) Rates]
    ,c.[Heart Attack Readmission Rates]
```

```
      ,c.[Heart Failure Mortality]
      ,c.[Heart Failure Readmission]
      ,c.[Pneumonia 30-day Mortality]
      ,c.[Pneumonia Readmission]
      /*,a.[F23] */
  FROM [Dec_12].[dbo].[HaentityID_MAX_applications] a
    join [2009_HIMSS_extracts].dbo.HAEntity b on a.HAEntityId = b.HAEntityId
  join [Spring_2011SQL].[dbo].[dbo_vwHQI_HOSP_HCAHPS_MSR] h on (b.Name = h.[Hospital Name] and
            b.state = h.State)
 join [2009_HIMSS_extracts].dbo.dbo_vwHQI_HOSP$ hh on (b.Name = hh.[Hospital Name] and b.state =
            hh.State)
  join [Dec_12].[dbo].['Patient Outcomes$'] c on c.[Provider Number] = h.[Provider Number]
GO

  FROM [Dec_12].[dbo].HAEntityApplication$)as x

  Group by HAEntityId
  order by HAEntityId
  go
```

APPENDIX C: STEPWISE REGRESSION RESULTS

```
Start:  AIC=681.46
Heart.Attack.Death ~ EDIS + Pharm_Man + Dictation + CDSS + Radiology_MRI +
    Card_IS + (EDIS * Pharm_Man * Dictation * CDSS * Radiology_MRI *
    Card_IS) + nofbeds + Hospital.Ownership + type + CMI

formula: Heart.Attack.Death ~ EDIS + Pharm_Man + Dictation + CDSS + Radiology_MRI + Card_IS + (EDIS * Pharm_Man *
Dictation * CDSS * Radiology_MRI * Card_IS) + nofbeds + Hospital.Ownership + type + CMI
data:    Dataset

 link  threshold nobs logLik  AIC    niter max.grad
 logit flexible  1467 -286.73 681.46 8(15) 2.15e-05

Coefficients: (17 not defined because of singularities)
                EDIS                          Pharm_Man                          Dictation
            1.159816                          -0.959512                          -0.286406
                CDSS                      Radiology_MRI                            Card_IS
            0.668339                          -0.039292                           0.341806
             nofbeds  Hospital.Ownership[T.Proprietary]    Hospital.Ownership[T.Voluntary]
           -0.001715                          -0.609485                          -0.793332
     type[T.General]                  type[T.Specialty]                                CMI
            1.064519                          -0.236407                          -0.361733
      EDIS:Pharm_Man                     EDIS:Dictation                Pharm_Man:Dictation
           -0.411968                          -1.168383                           0.992633
           EDIS:CDSS                     Pharm_Man:CDSS                     Dictation:CDSS
            1.422163                           0.179607                          -2.463525
  EDIS:Radiology_MRI            Pharm_Man:Radiology_MRI            Dictation:Radiology_MRI
```

```
                                  -1.278478                                     0.940019                                      0.178422
                         CDSS:Radiology_MRI                                 EDIS:Card_IS                             Pharm_Man:Card_IS
                                   0.352820                                    -4.145694                                      3.952201
                           Dictation:Card_IS                                 CDSS:Card_IS                         Radiology_MRI:Card_IS
                                  -0.428182                                     0.181582                                     -0.957720
                    EDIS:Pharm_Man:Dictation                          EDIS:Pharm_Man:CDSS                           EDIS:Dictation:CDSS
                                   0.276622                                    -2.426410                                      0.579007
                    Pharm_Man:Dictation:CDSS                 EDIS:Pharm_Man:Radiology_MRI                  EDIS:Dictation:Radiology_MRI
                                   2.184962                                     0.272205                                      1.386398
           Pharm_Man:Dictation:Radiology_MRI                      EDIS:CDSS:Radiology_MRI                  Pharm_Man:CDSS:Radiology_MRI
                                  -1.270682                                    -1.232895                                     -0.816847
                Dictation:CDSS:Radiology_MRI                        EDIS:Pharm_Man:Card_IS                        EDIS:Dictation:Card_IS
                                  -0.170831                                    -0.207133                                     -4.727103
               Pharm_Man:Dictation:Card_IS                             EDIS:CDSS:Card_IS                        Pharm_Man:CDSS:Card_IS
                                  -3.202147                                     3.858353                                     -3.715656
                    Dictation:CDSS:Card_IS                  EDIS:Radiology_MRI:Card_IS              Pharm_Man:Radiology_MRI:Card_IS
                                   2.485118                                     4.861870                                      0.305302
           Dictation:Radiology_MRI:Card_IS                   CDSS:Radiology_MRI:Card_IS                  EDIS:Pharm_Man:Dictation:CDSS
                                   1.107609                                    -0.197346                                            NA
      EDIS:Pharm_Man:Dictation:Radiology_MRI             EDIS:Pharm_Man:CDSS:Radiology_MRI             EDIS:Dictation:CDSS:Radiology_MRI
                                         NA                                     1.957803                                            NA
      Pharm_Man:Dictation:CDSS:Radiology_MRI              EDIS:Pharm_Man:Dictation:Card_IS                   EDIS:Pharm_Man:CDSS:Card_IS
                                         NA                                     6.349063                                      1.394223
                EDIS:Dictation:CDSS:Card_IS               Pharm_Man:Dictation:CDSS:Card_IS          EDIS:Pharm_Man:Radiology_MRI:Card_IS
                                         NA                                           NA                                     -3.867087
       EDIS:Dictation:Radiology_MRI:Card_IS      Pharm_Man:Dictation:Radiology_MRI:Card_IS               EDIS:CDSS:Radiology_MRI:Card_IS
                                         NA                                           NA                                     -3.347265
       Pharm_Man:CDSS:Radiology_MRI:Card_IS          Dictation:CDSS:Radiology_MRI:Card_IS       EDIS:Pharm_Man:Dictation:CDSS:Radiology_MRI
                                         NA                                           NA                                            NA
        EDIS:Pharm_Man:Dictation:CDSS:Card_IS  EDIS:Pharm_Man:Dictation:Radiology_MRI:Card_IS        EDIS:Pharm_Man:CDSS:Radiology_MRI:Card_IS
                                         NA                                           NA                                            NA
   EDIS:Dictation:CDSS:Radiology_MRI:Card_IS  Pharm_Man:Dictation:CDSS:Radiology_MRI:Card_IS EDIS:Pharm_Man:Dictation:CDSS:Radiology_MRI:Card_IS
                                         NA                                           NA                                            NA

Threshold coefficients:
Better than U.S. National Rate|No Different than U.S. National Rate  No Different than U.S. National Rate|Worse than U.S. National Rate
                                                             -4.668                                                               3.733
```